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TRACE ELEMENTS AND OIL-RELATED CONTAMINANTS IN SEDIMENT, BIVALVES, AND EELGRASS FROM PADILLA AND FIDALGO BAYS, SKAGIT COUNTY, WASHINGTON, 1988

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Abstract

Trace elements and oil-related contaminants in sediment, bivalves, and eelgrass in Padilla and Fidalgo Bays, Skagit County, Washington, 1988.

Padilla Bay is a tidal estuary in Puget Sound, Washington with extensive eelgrass beds and mudflats. The estuary is an important natural resource which provides habitat for a wealth of wildlife and aquatic life, including species of high economic value such as salmon and dungeness crab. Potential contaminant threats to Padilla Bay include spills and emissions from two large oil refineries, runoff from agricultural lands, and active and inactive landfills. The purposes of this study were to document existing contaminant concerns, and provide background information on contaminant levels in the event of an oil spill.

The U.S. Fish and Wildlife Service collected sediment, bivalves, and eelgrass samples from several sites throughout Padilla and Fidalgo Bays during the summer of 1988. Samples were analyzed for trace elements, polycyclic aromatic hydrocarbons (PAH), aliphatic hydrocarbons (AH), and organochlorine (OC) pesticides.

Overall, the results from this study indicated that the occurrences of elevated contaminant residues in Padilla Bay were few and localized. Statistical analyses were not conducted due to the limited number of samples.

Nickel in sediment exceeded biological effect levels at about half of the sites. Sites where nickel exceeded these levels occurred throughout the study area. Eight of the nine PAHs with identified biological effect levels were exceeded in a single sediment sample from the mouth of Joe Leary Slough. Chromium effect levels were exceeded in sediment from one site (Guemes Island), and zinc concentrations exceeded effect levels at two sites (No Name Slough, Little Indian Slough). Total AHs were found to be elevated in sediments at the mouth of Telegraph Slough.

Cadmium and chromium residues in littleneck clams, and arsenic residues in eelgrass were higher at the site closest to the March Point Landfill. Metal residues in softshell clams and PAH residues in both eelgrass and softshell clams were generally highest at the sites (MP3, FB4). These two sites were closest to the piers and pipelines used to transfer crude oil from tankers to the refineries on March Point and to associated discharge outfalls. These results are consistent with the shipping and industrial activity in the area. The contaminant residues measured in biota were not present at levels indicating a need for remediation.

Recommendations included: identify and examine the potential sources and the extent of nickel contamination in sediments throughout the study area; examine the extent of PAH contamination of sediments at Joe Leary Slough; and, conduct further remediation on March Point Landfill to control the discharge source of contaminants.

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Introduction

Padilla Bay, an estuary in Puget Sound, Washington, is an important natural resource, and is one of 22 sites in the National Estuarine Research Reserve System. It is composed of over 5,000 hectares of intertidal and subtidal sand, mudflats, and eelgrass beds (Bulthuis 1993). The eelgrass beds in Padilla Bay are one of the largest contiguous beds of seagrass along the Pacific Coast (Bulthuis 1991) and provide habitat for a wealth of wildlife, including several economically important species. Salmon smolts spend time foraging in the rich waters of Padilla Bay before embarking for life in the open ocean. The eelgrass beds serve as a nursery for dungeness and other species of crabs. The bay also is an important staging area for black brant. The brant consume eelgrass to build up energy reserves during spring and fall migrations. Estimates from waterfowl counts indicate that one third or more of the Pacific Flyway population of black brant may be present in Padilla Bay at one time.

The mud flats exposed during low tide receive heavy use from many species of shorebirds. The shorebirds are the prey of peregrine falcons, a Federal and State listed endangered species. Several bald eagle pairs nest along the shore or on the islands of Padilla Bay, and prey on the many species of fish and waterfowl occurring there. The bald eagle is a federally-listed threatened species.

Several small creeks entering Padilla Bay have the potential to transport contaminants into the bay. The sloughs at the mouth of the creeks support a diversity of life and are important refugia for aquatic life during low tides.

Although Padilla Bay is relatively isolated from human activity, several possible threats to water quality exist. Potential contaminant sources include the Texaco and Shell oil refineries on March Point (Figure 1) and associated oil tanker traffic; runoff from agricultural activities, a major land use accounting for about 65% of the Padilla Bay watershed (Bulthuis 1993); boat traffic from the Swinomish Channel; and several active and inactive landfills.

In this study, sediment, bivalves, and eelgrass were analyzed for trace elements, organochlorine pesticides, polycyclic aromatic hydrocarbons and aliphatic hydrocarbons. The incentive for this study was provided by two oil spills occurring in March and April of 1988, of 500 and 5,000 gallons, respectively. The purposes of this study were to investigate Padilla Bay for significant contaminant concerns, and to establish background concentrations of refinery-related contaminants for future comparisons in the case of another oil spill. The small volumes, limited movement, and cleanup efforts associated with the two spills prior to sample collection indicate that, with the exception of the Guemes Island sampling site, results from this study are appropriate for establishing background conditions.

Methods

Sample collection. Thirty-three sediment samples were collected from Padilla, Fidalgo, and Samish Bays. Padilla and Fidalgo Bay samples were collected between 26 July and 4 August, 1988. Sampling sites (Figure 1) are identified by codes which correspond to the first half of sample numbers listed in the tables and appendices. No information was available on the dates and locations for

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Samish Bay sediment samples. Results of Samish Bay sediment analyses are provided in appendices but are, for the most part, not discussed.

Sediment sampling sites were selected to examine refinery activities at March Point (MP# sites) and Fidalgo Bay (FB# sites), the March Point landfill (LF# sites) and the Inman landfill at Joe Leary Slough (JL1 site). Nonpoint source pollution entering Padilla Bay was examined at No Name Slough (NN1), Indian Slough (IS1), Little Indian Slough (LI1), and Big Indian Slough (BI1). Sediment was collected with either a ponar grab or a shovel, and samples consisted of composites of multiple grabs. Additional sediment samples were collected to examine ambient conditions in Padilla Bay (PB# sites) and at Guemes Island (GI1).

Eleven bivalve samples were collected from Padilla and Fidalgo Bays (Figure 1). Three species of bivalves were collected, because no single species was available at all sites. Littleneck clams (*Protothaca staminea*) were collected at six of the eleven sites, softshell clams (*Mya arenaria*) were collected at four sites, and American oysters (*Crassostrea gigas*) were collected at one site. The abbreviations LNC, SSC, and OYS in the second half of the sample numbers listed in tables and appendices were used to indicate species. Bivalves were dug from mudflats at low tide with a shovel, measured for length, shucked, and weighed. At each site, ten individuals of a single species were composited into a single sample. Two samples were collected at MP3 site, one each of littleneck and softshell clams. Mean length and weight for each bivalve sample are provided in Appendix A.

Two species of eelgrass, *Zostera marina* and *Z. japonica*, were collected from eight sites in Padilla, Fidalgo, and Samish Bays. Identification of the species was recorded for only a few samples. Most samples are likely to be *Z. marina*, as this species covers approximately ten times more area in Padilla Bay than *Z. japonica* (Bulthuis 1991). Numerous individuals were composited for analysis. Eight samples were analyzed for trace elements. Five samples were analyzed for PAHs and AHs.

<u>Chemical Analysis</u>. Sediment, bivalve, and eelgrass samples were analyzed for organochlorines (OC), aliphatic hydrocarbons (AH), and polycyclic aromatic hydrocarbons (PAH) by Mississippi State Chemical Laboratory, Mississippi State University. The analytical methods are detailed in Appendix B. Detection limits for OCs, AHs, and PAHs were 0.01 $\mu g/g$ wet weight, with the exceptions of total PCBs and toxaphene, which were 0.05 $\mu g/g$.

Sediment, bivalve, and eelgrass samples were analyzed for trace elements by Environmental Trace Substances Research Center, Columbia, MO. Trace element concentrations were quantified by Inductively Coupled Plasma (ICP) with the following exceptions: 1) arsenic and selenium were quantified by hydride generation; and, 2) mercury was quantified by cold vapor atomic absorption. Detailed analytical methods are provided in Appendix C; detection limits are reported in Table 1. Complete analytical results of the samples are provided in Appendices D through H.

In addition to chemical analyses, percent moisture was determined for all samples, percent lipids for bivalve samples, and percent total volatile solids (TVS) for sediment samples. Quality assurance (QA) and quality control (QC)

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procedures included analysis of duplicates, laboratory blanks, and certified materials. QA/QC results were reviewed by the USFWS Patuxent Analytical Control Facility and determined to be acceptable. Statistical analyses were not conducted due to the limited number of samples.

Results

Trace Elements. Sediment samples were analyzed for 21 trace elements. Of these, molybdenum and thallium were not detected in any sample. Trace element concentrations in sediments from Padilla, Fidalgo, and Samish Bays were compared to several standards and guidelines (Table 2). The Marine Sediment Quality Standards established by the State of Washington (WAC 173-204-320, April 1991) correspond to a sediment quality that will result in no adverse effects, including no acute or chronic adverse effects on biological resources, and no significant health risk to humans. None of the sediment samples exceeded concentrations of those trace elements for which standards have been established.

The National Status and Trends Program has identified effect levels for contaminant concentrations in sediment based on review of numerous studies where sediment concentrations were related to biological effects (Long and Morgan 1991). For a particular contaminant, sediment concentrations associated with biological effects were ranked, and two concentrations were calculated. The Effects Range-Low (ER-L) was based on the lower 10th percentile concentration, and the Effects Range-Medium (ER-M) on the median concentration at which biological effects occurred.

For nickel, ten sediment samples exceeded the ER-L and six of those samples exceeded the ER-M. Zinc concentrations in sediments exceeded the ER-L at No Name Slough and exceeded the ER-M at Little Indian Slough. The chromium concentrations in sediments exceeded the ER-M at Guemes Island.

Trace element concentrations in sediment samples were closely related to percent TVS, with the exceptions of lead and strontium. Percent TVS is a measurement related to percent organic matter. Fine-grained organic sediments will physically bind trace elements in greater concentrations relative to larger grain sizes, as they have a greater surface to volume ratio for adsorption. In addition, the clay-mineral component of the sediments attract and bind divalent trace element cations.

The upper slough sites sampled (LI, BI, NN, and JL, Figure 1) contained higher concentrations of trace elements relative to other sites. As these were also the sites with the highest values for percent TVS, elevated concentrations are probably related to sediment grain size rather than a possible contaminant source. The data were not normalized to percent TVS.

The three bivalve species analyzed in this study differed in their accumulation of several trace elements. Concentrations of cadmium, copper, and zinc were clearly different between the three species and were highest in oysters (Figure 2). Copper and zinc concentrations were also found to differ between mussels and oysters sampled in the National Status and Trends Program (NOAA 1989). The single oyster sample from this study also contained more manganese than the other two species. Much higher concentrations of several elements in oysters

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may have been associated with their larger size and related ability to filter larger volumes of water.

Biological samples were not collected adjacent to the March Point Landfill. The bivalve and eelgrass sampling site closest to the landfill was PB7 (Figure 1). Biological samples from this site contained the highest concentrations of the following metals relative to the other study sites: arsenic in eelgrass; and, cadmium and chromium in littleneck clams (Figure 3).

Several trace elements in softshell clams and eelgrass from the site closest to the refinery piers (MP3) were higher relative to other sites in this study. Trace elements relatively elevated in softshell clams samples from MP3 were arsenic, chromium, iron, manganese, lead, and zinc (Figure 4). Eelgrass from MP3 contained the highest concentration of beryllium and lead (Figure 5). Trace element concentrations in sediment and littleneck clams from MP3 were not elevated relative to the other sites.

Littleneck clams from PB2 contained elevated concentrations of mercury and nickel (Figure 6) relative to the other sites. The concentrations of selenium (4.8 $\mu g/g$ dry weight) and zinc (87.7 $\mu g/g$ dry weight) were highest in littleneck clams from this site (Appendix E).

Littleneck clams have been collected frequently for Puget Sound contaminant studies. Concentrations of the priority pollutant metals of arsenic, cadmium, copper, lead, and mercury varied little between sites, including reference sites and sites near highly industrialized areas. Concentrations of priority pollutant metals in Padilla Bay littleneck clams were comparable to those measured in littleneck clams from other areas in Puget Sound (Table 3).

<u>Polycyclic Aromatic Hydrocarbons</u>. In general, PAH concentrations in sediment were below Washington Marine Sediment Quality Standards and National Status and Trends effects-based levels (Long and Morgan 1991). Sediment PAH concentrations from Padilla and Fidalgo Bays were in the low end of ranges of concentrations from sites throughout the world compiled by Johnson et al. (1985). However, sediment from Joe Leary Slough (JL1) had much higher PAH concentrations than all other sites from this study (Table 4), exceeding all but one ER-L value for the nine PAH compounds analyzed for which effect levels have been determined (Table 5). Sediments from Samish Bay and from March Point Landfill had somewhat higher mean concentrations of total PAHs compared to the other sites (Table 4).

Concentrations of PAHs in bivalve samples were not elevated relative to the studies described below. Concentrations of total PAHs in softshell clams from this study (<0.01-0.04 $\mu g/g$ wet weight) were similar to those in the same species from an industrialized area of Coos Bay, Oregon (0.006-0.02 $\mu g/g$ wet weight; Mix and Schaffer 1983).

The National Status and Trends Program (NOAA 1989) reported PAH concentrations in mussels as total low molecular weight and total high molecular weight PAHs. Differences in PAH compounds analyzed between the two studies prevented direct comparison of total low molecular weight PAHs. Concentrations of total high molecular weight PAHs in Padilla Bay bivalves were much lower than those in mussels from the nine National Status and Trends Program sites located in Washington. Total high molecular weight PAHs in Padilla Bay bivalves ranged

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from below detection limits to 0.54 μg/g dry weight, while the nine mussel samples mentioned above ranged from below detection limits to 15 μg/g, with a mean of 2.6 μg/g dry weight.

In general, PAH concentrations in biota samples were similar between sites. Concentrations were somewhat higher in littleneck clams from MP3 and in littleneck clams and eelgrass from Fidalgo Bay relative to other samples in the study (Figure 7). Unlike many trace elements, PAH concentrations showed no clear differences between bivalve species.

Aliphatic Hydrocarbons. The AH concentrations in sediments and bivalves generally were not elevated relative to the studies available for comparison. Because petroleum can occur naturally in the environment, background concentrations in sediment are quite variable, between 1 and 500 μg/g (Moore and Ramamoorthy 1984). Total sediment AH concentrations for Padilla, Fidalgo, and Samish Bays were in the low end of this range (0.02 - 21.31 μg/g wet weight, Appendix H). Total AH concentrations in bivalves (0.17 - 0.42 μg/g wet weight, Appendix H) were also lower than those of invertebrates exposed to chronic pollution (1-150 μg/g, Moore and Ramamoorthy 1984). No data on AHs in eelgrass were available for comparison.

In samples of sediment, bivalves, and eelgrass, heptadecane occurred at consistently higher concentrations than other aliphatics. In eelgrass, pentadecane occurred at concentrations similar to heptadecane. Heptadecane is one of the larger, and therefore more persistent, aliphatics associated with fuel oils (Verschueren 1983).

In general, concentrations of AHs in eelgrass and bivalves were relatively consistent between sites. However, total AHs (21.31 μg/g wet weight) in sediment at Telegraph Slough (PB5; Figure 1), were much higher than at other sites (Table 6).

As the branched aliphatics, pristane and phytane, are more readily bioaccumulated in tissues, high ratios of pristane:heptadecane and phytane: octadecane can indicate chronic exposure of biota (Hall and Coon 1988). In both bivalves and eelgrass, heptadecane and octadecane concentrations were higher than the corresponding pristane and phytane concentrations (Appendix H) suggesting that chronic exposure to AHs is not ongoing.

Organochlorines. For the most part, OCs were not detected in sediment or bivalve samples. Eelgrass was not analyzed for OCs. The two exceptions were sediment samples from PB6 and NN1 (Figure 1) which both contained traces of p,p'DDE (0.01 μg/g wet weight). These results are typical for sediment in agricultural areas.

Discussion

Overall, the results from this study indicated that the occurrences of elevated contaminant residues in Padilla Bay were few and localized. With the exception of nickel concentrations at about half the sites, sediment criteria and/or effect levels generally were not exceeded for trace elements or PAHs. Sites where nickel concentrations in sediment exceeded effects-based levels occured throughout the study area, suggesting a geological source. Potential sources of nickel should be investigated however, because nickel concentrations may be impacting biota, as indicated by exceedence of effect levels.

Sediment from the mouth of Joe Leary Slough contained concentrations of total PAHs an order of magnitude higher than other sites in this study and exceeded the National Status and Trends effects-based levels (Long and Morgan 1991) for eight of the nine PAH compounds for which effect levels have been determined. The potential source(s) of elevated PAHs may include: nonpoint source runoff from Interstate 5 and the upstream town of Burlington; improper disposal of waste motor oils from an upstream migrant labor camp; and/or, burning of wood and yard waste at the Inman Landfill located about one mile inland from the Padilla Bay shoreline. Further study of PAHs in sediment of Joe Leary Slough is recommended as concentrations may be associated with biological impacts. The source and extent of PAH contamination should be determined.

The study identified areas where several contaminants were elevated relative to other sites in this study. Several trace element residues were higher in littleneck clams and eelgrass from the sites closest to the March Point Landfill. The landfill was opened in the mid-1950's and received a variety of metallic wastes, inorganic and organic compounds, and household and construction debris until it was closed and capped in 1974 (U.S. Environmental Protection Agency 1988). Leachate can be observed in the tideflats located offshore of the landfill and in an tidal stream located along the edge of the fill separated from the bay by railroad embankment.

Several other studies have examined the March Point Landfill for pollution problems. Sediment and water were analyzed for EPA priority pollutants by the Washington Department of Ecology (Milham 1986), and it was concluded that the data did not show that a significant problem existed at the landfill. However, leachate was analyzed in 1988 (Fitzpatrick 1989), and several trace elements were elevated above acute marine water quality standards (WAC 173-201). In particular, copper, nickel, and zinc, were found to be elevated one to two orders of magnitude above the water quality standards.

Two bioassay studies showed toxicity ranging from 60 to 100 percent mortality to the amphipod *Rhepoxynius abronius* from sediment collected near the landfill (Wiggins 1992; Bulthuis and Shaw 1992). Thus, the preponderance of evidence suggests that leachate from the March Point Landfill is contributing contaminants to Padilla Bay. Results from sediment bioassays suggest that localized impacts to sediment-associated organisms may be occurring. However, the extent and severity of these impacts have not been fully determined. Further evaluation of the landfill is recommended to identify actions to remediate the contaminant input into Padilla Bay.

Trace element and PAH residues were generally higher in softshell clams and eelgrass samples from sites (MP3, FB4) closest to the piers and pipelines used to transfer crude oil from tankers to the refineries on March Point and to the associated discharge outfalls. These results are consistent with the shipping and industrial activity of the area. However, as criteria have not been established for these sample types, it is unknown whether the contaminant concentrations present would result in chronic toxicity problems to eelgrass and clams, or to the species which consume them. Sediment bioassays using

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Rhepoxynius abronius and *Crassostrea gigas* did not show significant toxicity at refinery effluent discharge areas (CH2M Hill 1992a, 1992b).

Based upon the findings of this study, the following recommendations are provided:

1) Potential sources and the extent of contamination of nickel, which occurred throughout the study area should be examined, as nickel residues exceeded known biological effect levels and may be impacting aquatic biota.

2) Potential sources and extent of contamination of PAHs at Joe Leary Slough should be examined, as these contaminants occurred above biologically based effect levels and may be causing impacts to biota.

3) Existing evidence indicates that March Point Landfill leachate is contributing contaminants to Padilla Bay and it has been demonstrated to cause impacts to biota. Further remediation is strongly advised for the landfill.

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Table 1. Detection limits for trace elements (μg/g dry weight) in sediment and biota collected from Padilla, Fidalgo, and Samish Bays, Washington, 1988.

Trace Element	Sediment Detection Limit[1]	Sediment Range	Biota Detection Limit[1]	Biota Range
Ag	2	2 - 3	n.a.[2]	
Al	3		0.4	0.3 - 5
As	0.1	0.1 - 0.2	0.1	0.1 - 2
B	4		n.a.	
Ba	0.1		n.a.	
Be	0.1		0.3	
Cd	0.6	0.6 - 0.9	0.06	0.05 - 0.07
Cr	2		0.3	0.2 - 0.3
Cu	0.2	0.2 - 0.3	0.02	0.02 - 0.04
Fe	1	1 - 40	0.1	0.1 - 4.0
Hg	0.02		0.006	
Mg	1		n.a.	
Mn	0.6	0.6 - 2.0	0.1	0.1 - 0.2
Mo	2	2 - 9	n.a.	
Ni	3		1.0	0.9 - 1.0
Pb	5	4 - 6	0.5	0.5 - 0.8
Se	0.2		0.2	
Sr	0.1		n.a.	
Tl	5	5 - 6	0.5	0.4 - 0.8
V	0.4	0.3 - 0.5	n.a.	
Zn	0.5	0.4 - 1.0	0.07	0.06 - 0.2

[1] Most frequently occurring detection limit when more than one was reported
[2] Not analyzed in biota

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Table 2. Trace elements in sediment (μg/g dry weight) from Padilla, Fidalgo, and Samish Bays, compared to Washington Sediment Criteria and effects-based levels from the National Status and Trends Program (Long and Morgan 1991).

Trace Element	Sample Range	WA Sediment Quality Criteria	NS&T ER-L[A]	# Sites Exceeding ER-L	NS&T ER-M[B]	# Sites Exceeding ER-M
Ag	<2 - 4		1.0	[C]	2.2	3
Al	8410 - 41600					
As	2.9 - 18.4	57	33		85	
B	3.1 - 32					
Ba	26.5 - 102.5					
Be	<0.1 - 0.81					
Cd	<0.6 - 1	5.1	5		9	
Cr	16 - 160	260	80		145	1
Cu	6.9 - 62.7	390	70		390	
Fe	9390 - 105000					
Hg	<0.02 - 0.079	0.41	0.15		1.3	
Mg	4720 - 16100					
Mn	106 - 521					
Mo	not detected					
Ni	15 - 180		30	10	50	6
Pb	<4 - 17	450	35		110	
Se	<0.02 - 0.6					
Sr	38.8 - 297					
Tl	not detected					
V	17 - 85.9					
Zn	25 - 283	410	120	1	270	1

[A] Effects Range - Lower
[B] Effects Range - Medium
[C] Criteria lower than detection limit

Table 3. Trace element concentrations, mean and range (μg/g wet weight), in littleneck clams from studies conducted throughout Puget Sound.

Trace Element	Padilla Bay (n=6)	Puget Sound[A] (n=?)	Eagle Harbor[B] (n=3[1])	McNeil Island[C] (n=3)	Bellingham Bay[D] (n=2)	Puget Sound[E] (n=8[2])	Puget Sound[F] (n=4)
As	3.08 (2.34-3.80)	- (0.3-2.0)	2.2 (1.5-2.6)	1.3 (1.1-1.4)	- (1.11-1.62)	2.7 (1.3-4.1)	- (1.4-2.1)
Cd	0.35 (0.13-0.54)	0.28 (0.15-0.40)	0.24 (0.14-0.29)	0.32 (0.29-0.35)	- (0.216-0.229)	0.32 (0.10-0.54)	- (0.14-0.230
Cr	0.31 (0.14-0.75)	--	0.26 (0.08-0.59)	0.19 (nd[3]-0.27)	--	--	--
Cu	1.19 (0.97-1.55)	--	--	0.85 (0.68-0.99)	--	--	- (0.96-1.4)
Hg	0.03 (0.02-0.04)	--	0.036 (0.010-0.068)	0.01 (0.0097-0.012)	- (nd-0.01)	0.02 (nd-0.03)	- (0.010-0.028)
Ni	0.74 (0.36-1.37)	--	1.06 (0.37-1.90)	--	--	--	--
Pb	nd (nd-0.11)	0.54 (0.25-0.80)	0.93 (0.43-1.32)	--	- (0.02-0.15)	0.09 (0.04-0.18)	- (nd-0.15)
Zn	11.5 (11.1-12.1)	16.7 (11-25)	13.6 (12.7-14.0)	13.5 (10.0-16.0)	--	--	- (10-16)

1 samples contained a majority of littleneck clams
2 non-reference sites only
3 not detected
\- unable to calculate a mean
-- no data

A Olsen and Schell 1977
B Yake et al. 1984
C Norton 1988
D Cubbage 1991
E Faigenblum 1988
F Pepe and Plews 1991

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Table 4. Elevated concentration of total PAHs in sediment ($\mu g/g$ wet weight) at Joe Leary Slough compared to other areas of Padilla, Fidalgo, and Samish Bays, Skagit County, Washington, 1988.

Sites or Areas	Site Numbers	Mean	Range
Joe Leary Slough	JL1	11.38	---
Padilla Bay sites	PB1 - PB7	0.04	0.02 - 0.09
March Point sites	MP1 - MP3	0.13	0.03 - 0.26
Fidalgo Bay sites	FB1 - FB4	0.34	0.09 - 0.85
March Point Landfill	LF1, LF2	0.64	0.42 - 0.51
Other Sloughs	NN1, LI1, BI1, IS1	0.07	0.02 - 0.08
Samish Bay sites	SB1 - SB6	0.63	0.03 - 1.77

Table 5. Concentrations of PAH compounds ($\mu g/g$ dry weight) in sediment from the mouth of Joe Leary Slough compared to effects-based levels from the National Status and Trends Program (Long and Morgan 1991).

PAH Compound	Joe Leary Slough	ER-L	ER-M
Anthracene	0.10	0.085	0.96
Benzo(a)pyrene	0.83	0.40	2.5
Chrysene	1.1	0.40	2.8
1,2,5,6 dibenzanthracene	0.05	0.06	0.26
Fluoranthene	3.6	0.60	3.6
Fluorene	0.03	0.035	0.64
Phenanthrene	0.28	0.225	1.38
Pyrene	2.1	0.35	2.2
Total PAHs	11.38	1.0	35.0

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Table 6. Elevated concentrations of total AHs in sediment (μg/g wet weight) at site PB5 compared to other areas of Padilla, Fidalgo, and Samish Bays, Skagit County, Washington, 1988.

Sites or Areas	Site Numbers	Mean	Range
Site PB5	PB5	21.31	---
Padilla Bay sites	PB1, PB2, PB3, PB4, PB6, PB7	0.25	0.18 - 0.40
March Point sites	MP1 - MP3	0.39	0.22 - 0.71
Fidalgo Bay sites	FB1 - FB4	0.84	0.18 - 2.26
March Point Landfill	LF1, LF2	1.06	0.41 - 1.71
Sloughs	JL1, NN1, LI1, BI1, IS1	0.20	0.16 - 0.24
Samish Bay sites	SB1 - SB6	0.26	0.02 - 0.47

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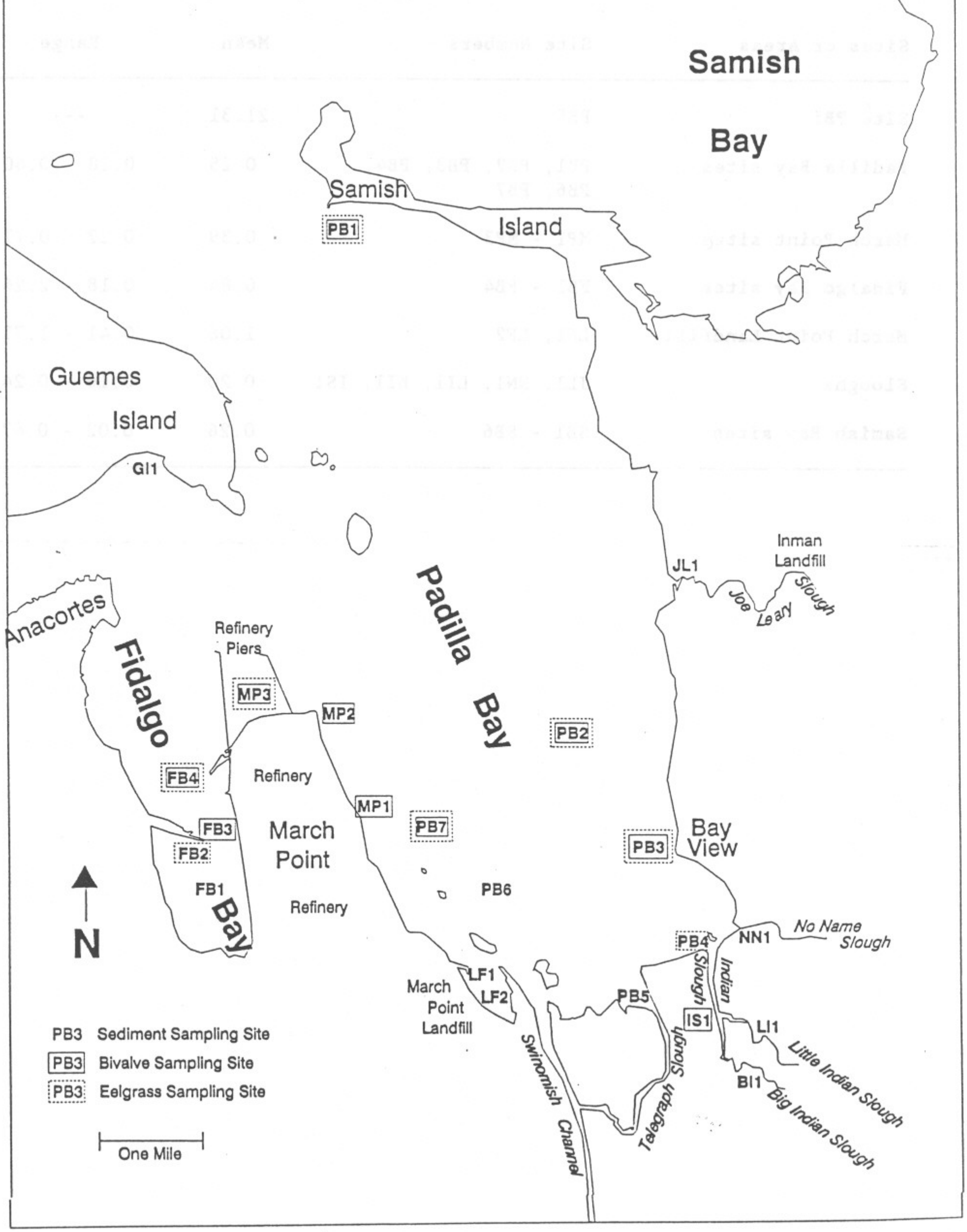
Figure 1. Locations of sampling sites in Padilla and Fidalgo Bays, Skagit County, Washington, 1988.



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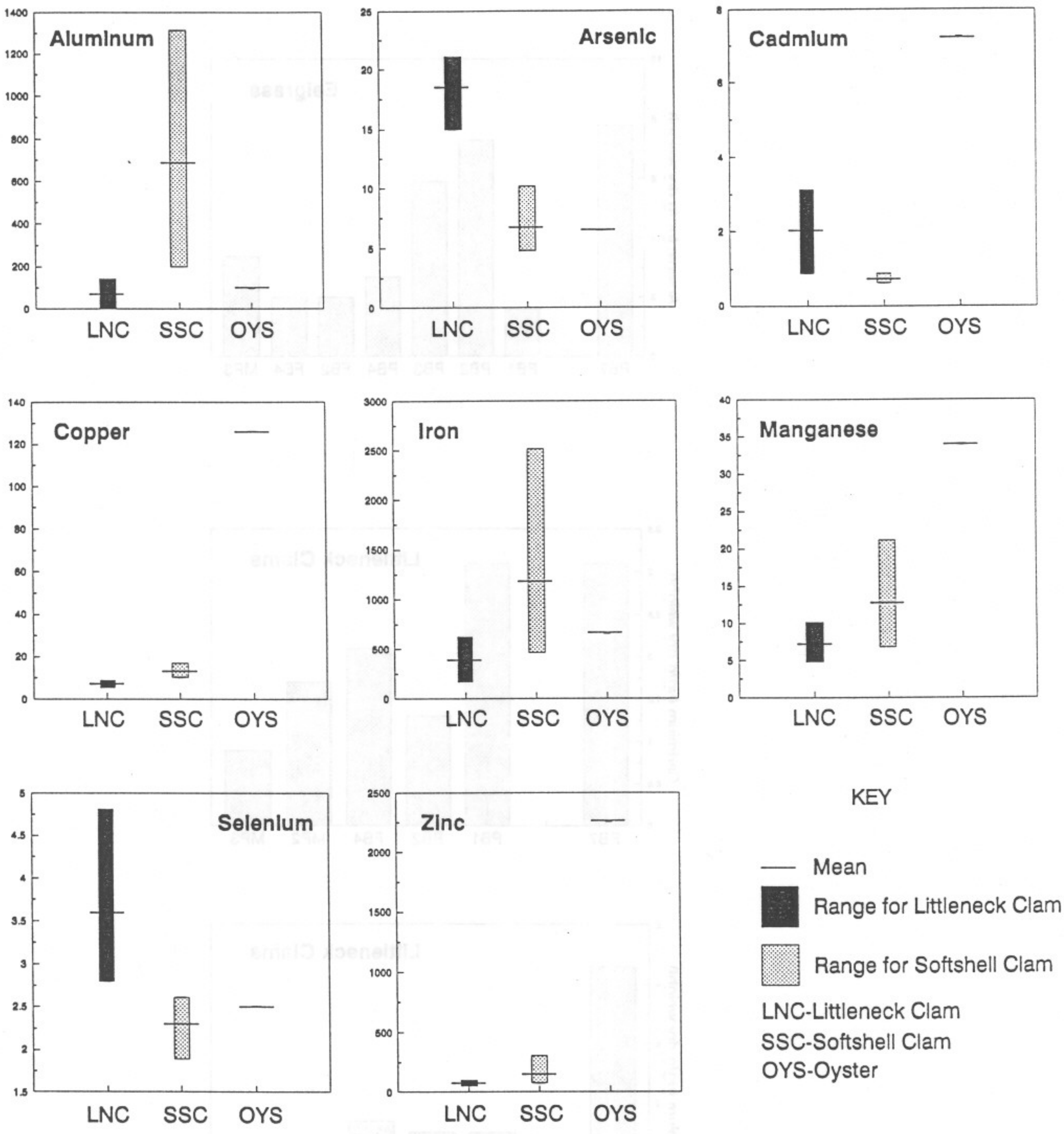

Figure 2. Concentrations of several trace elements (μg/g dry weight) differed between species of bivalves collected from Padilla and Fidalgo Bays, Skagit County, Washington, 1988.

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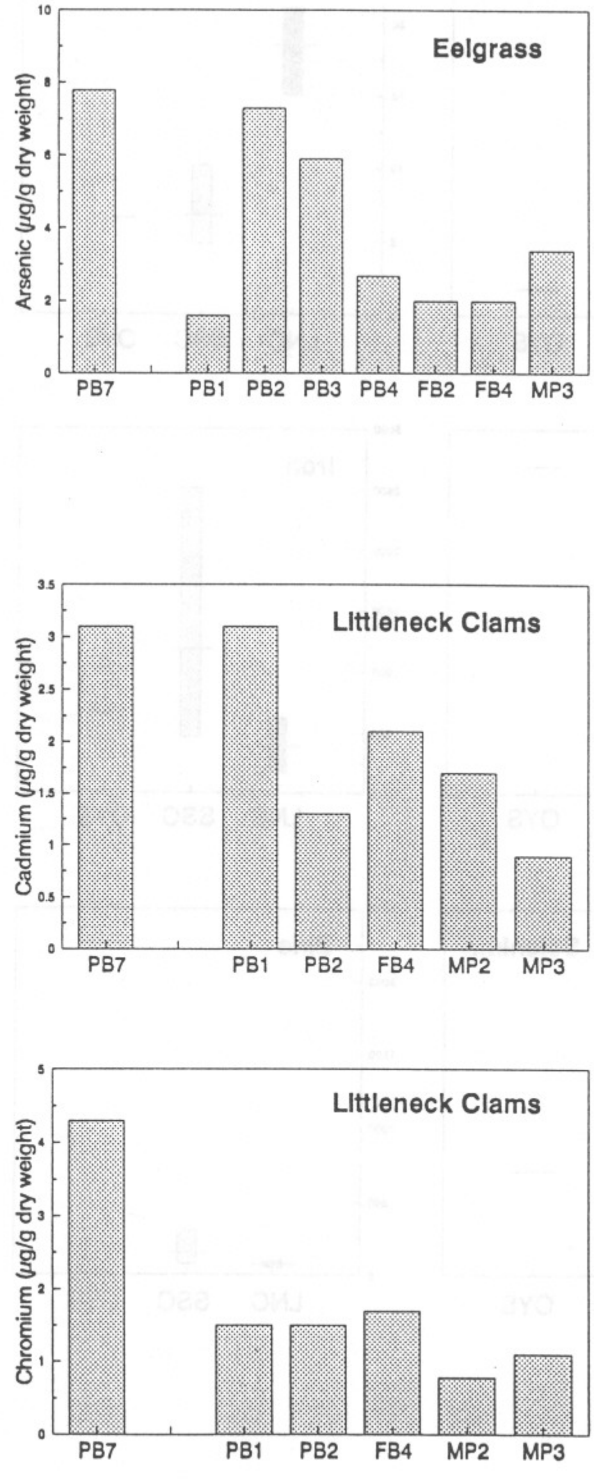

Figure 3. Concentrations of several trace elements in eelgrass and clams collected near the March Point Landfill (PB7) were elevated relative to other sites in Padilla and Fidalgo Bays, Skagit County, Washington, 1988.

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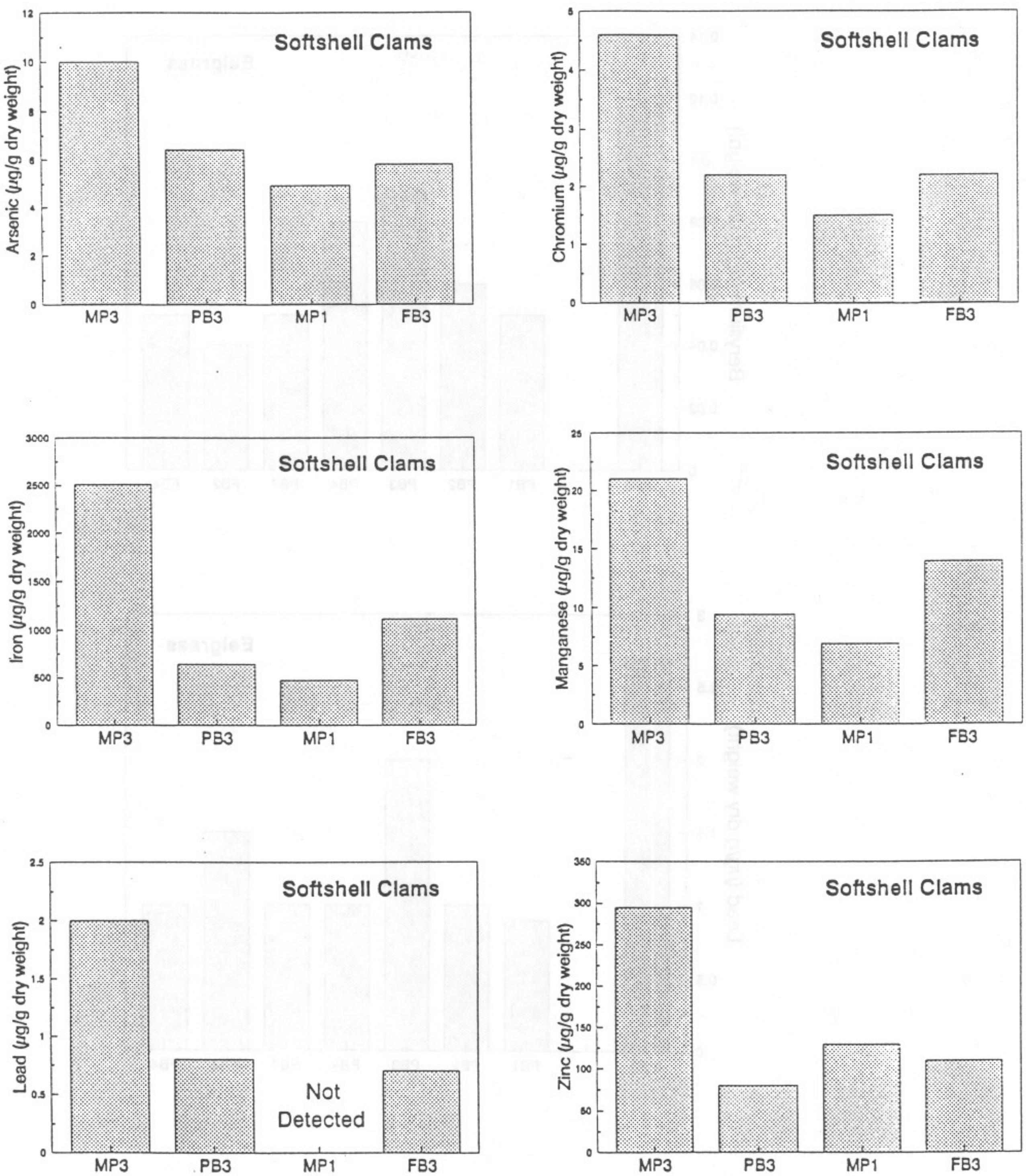

Figure 4. Concentrations of several trace elements in softshell clams were elevated near the oil refinery piers (MP3) relative to other sites in Padilla and Fidalgo Bays, Skagit County, Washington, 1988.

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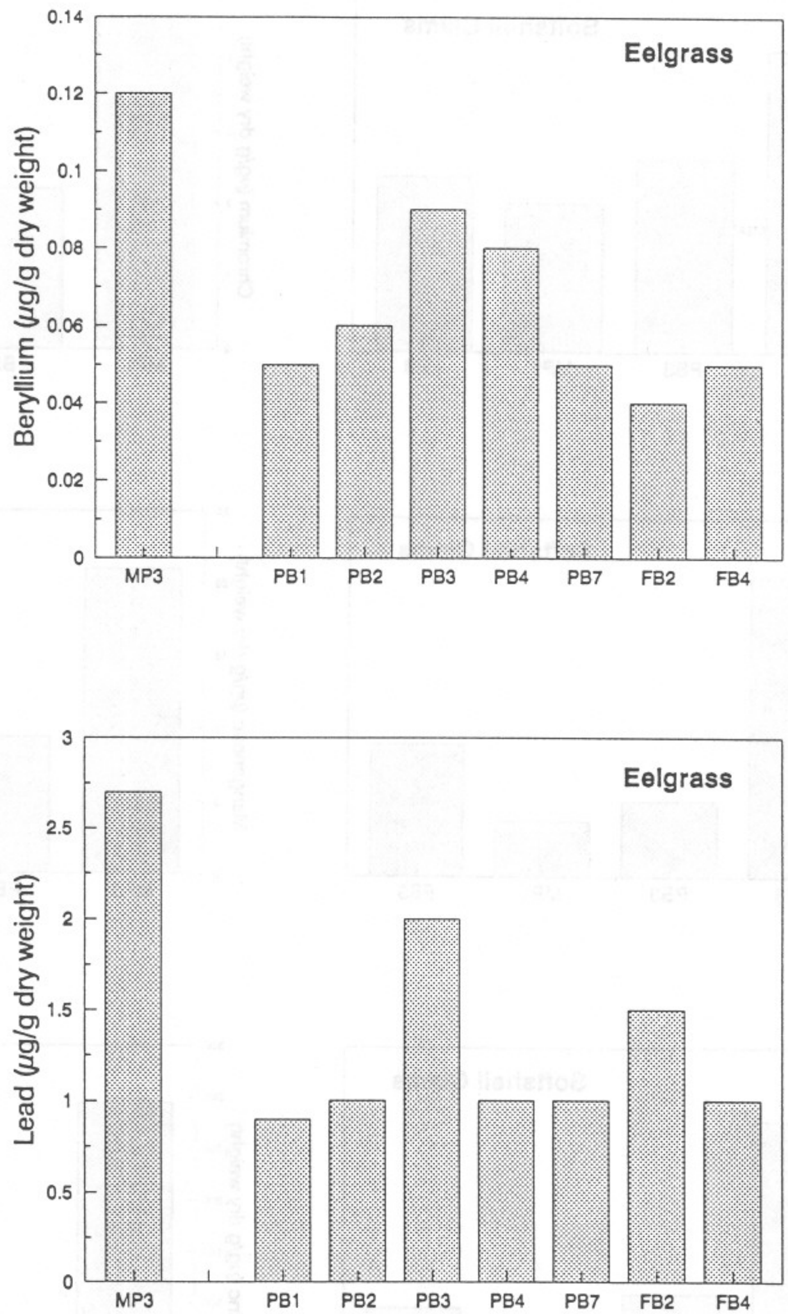

Figure 5. Concentrations of beryllium and lead in eelgrass were elevated near the oil refinery piers (MP3) relative to other sites in Padilla and Fidalgo Bays, Skagit County, Washington, 1988.

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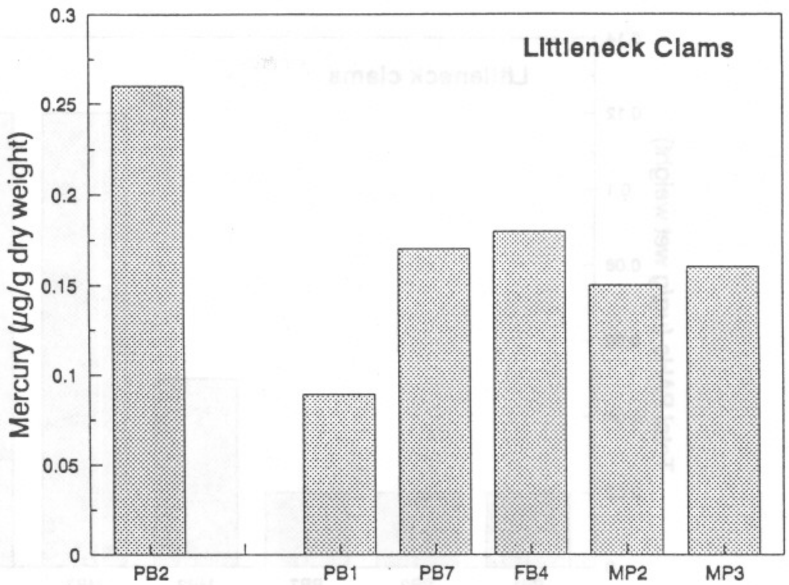

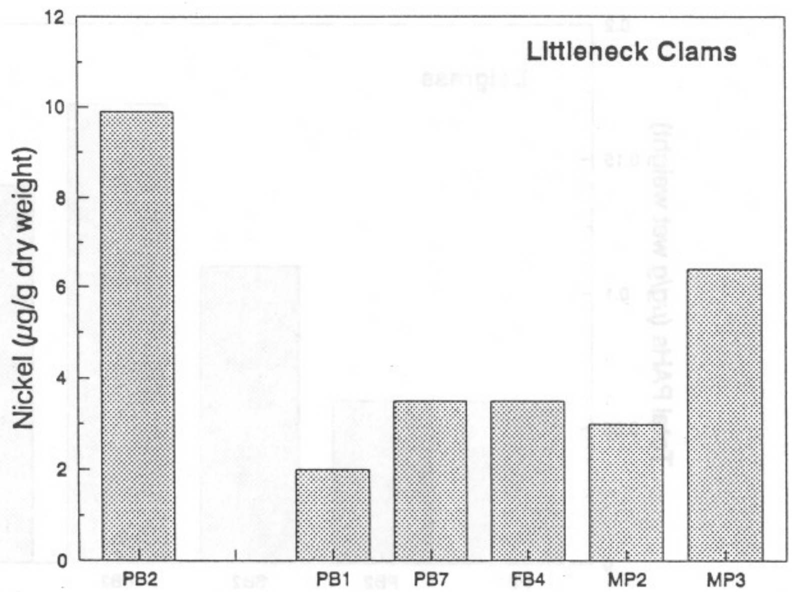

Figure 6. Concentrations of mercury and nickel in littleneck clams at site PB2 were elevated relative to other sites in Padilla and Fidalgo Bays, Skagit County, Washington, 1988.

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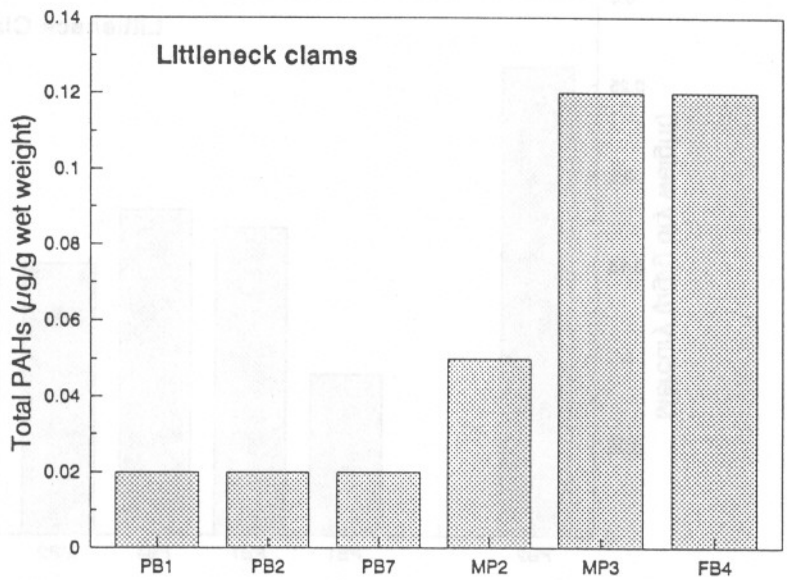

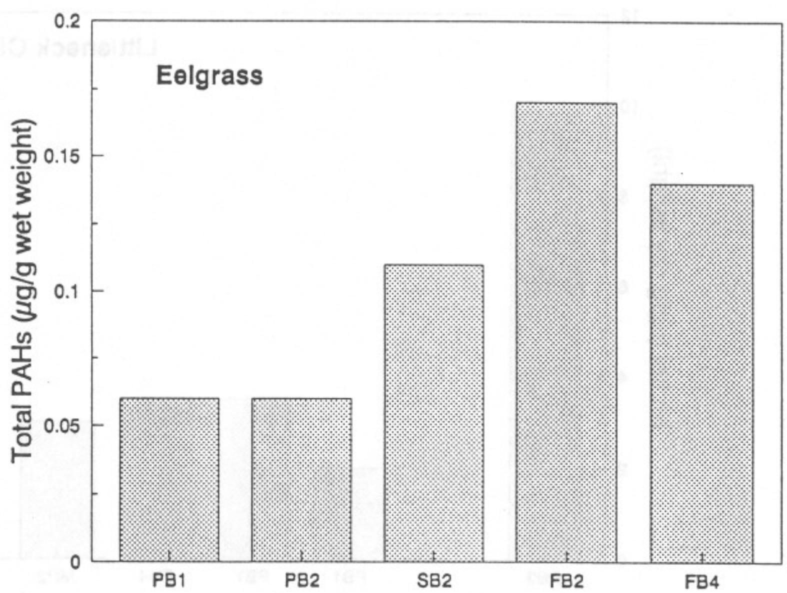

Figure 7. Concentrations of total PAHs in littleneck clams and eelgrass were elevated near oil refinery sites (MP3, FB2, and FB4) relative to other sites in Padilla and Fidalgo Bays, Skagit County, Washington, 1988.

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APPENDICES

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Appendix A. Mean length and weight of composite bivalve samples (n=10 per sample). LNC = littleneck clams; SSC = softshell clams; OYS = oyster.

Sample Number	Mean Length (mm)	Mean Weight (g)
PB1-LNC	52.4	13
PB2-LNC	49.15	14
PB7-LNC	50.75	9
MP2-LNC	51.84	12
MP3-LNC	46.24	10
FB4-LNC	51.09	9
PB3-SSC	53.19	12
MP1-SSC	40.4	5
MP3-SSC	40.86	5
FB3-SSC	44.52	6
IS1-OYS	208	113

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APPENDIX B

Analytical Methods for Organic Chemicals.

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Method 1. <u>Analysis For Organochlorine Pesticides and PCBs In Animal and Plant Tissue.</u>

Ten gram tissue samples are thoroughly mixed with anhydrous sodium sulfate and soxhlet extracted with hexane for seven hours. The extract is concentrated by rotary evaporation; transferred to a tared test tube, and further concentrated to dryness for lipid determination. The weighed lipid sample is dissolved in petroleum ether and extracted four times with acetonitrile saturated with petroleum ether. Residues are partitioned into petroleum ether which is washed, concentrated, and transferred to a glass chromatographic column containing 20 grams of Florisil. The column is eluted with 200 ml 6% diethyl ether/94% petroleum ether (Fraction I) followed by 200 ml 15% diethyl ether/85% petroleum ether (Fraction II). Fraction II is concentrated to appropriate volume for quantification of residues by packed or capillary column electron capture gas chromatography. Fraction I is concentrated and transferred to a Silicic acid chromatographic column for additional cleanup required for separation of PCBs from other organochlorines. Three fractions are eluted from the silicic acid column. Each is concentrated to appropriate volume for quantification of residues by packed or megabore column, electron capture gas chromatography. PCBs are found in Fraction II.

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Method 4. Analysis For Aliphatic and Aromatic Hydrocarbons In Soil and Sediment.

Twenty gram soil or sediment samples are extracted with acetone, followed by petroleum ether, by allowing to soak one hour in each with intermittent shaking. A final acetone/petroleum ether extraction is done, and the extracts are combined, centrifuged, and transferred to a separatory funnel containing sufficient water to facilitate partitioning of residues into petroleum ether portion. The petroleum ether is washed twice with water and concentrated by Kuderna-Danish to appropriate volume for transfer to a 20 gram 1% deactivated silica gel column, topped with five grams neutral alumina. Aliphatic and polynuclear aromatic hydrocarbon residues are fractionated by eluting aliphatics from the column with 100 ml petroleum ether (Fraction I) followed by elution of aromatics using first, 100 ml 40% methylene chloride/60%petroleum ether, then 50 ml methylene chloride (Combined eluates, Fraction II). If needed, Fraction I containing aliphatics is subjected to additional cleanup by concentration and transfer to a deactivated (2% water) Florisil column. Aliphatic residues are eluted from the Florisil column using 200 ml 6% diethyl ether/94% petroleum ether. The eluate is concentrated to appropriate volume for quantification by capillary column, flame ionization gas chromatography. The silica gel Fraction II containing aromatic hydrocarbons is concentrated, reconstituted in methylene chloride, and subjected to gel permeation chromatographic (GPC) cleanup prior to quantification by capillary, flame ionization gas chromatography and fluorescence HPLC.

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B. Florisil Mini-Column:

1. Fraction I (12 ml hexane followed by 12 ml 1% methanol in hexane)
   HCB, gamma-BHC (25%), alpha-BHC (splits with FII), trans-nonachlor, o,p'-DDE, p,p'-DDE, o,p'-DDD, p,p'-DDD (splits with FII), o,p'-DDT, p,p'-DDT, mirex, cis-nonachlor, cis-chlordane, trans-chlordane, PCB's, Photomirex and derivatives.
2. Fraction II (24 ml 1% methanol in hexane)
   gamma BHC (75%), beta-BHC, alpha-BHC (splits with FI), delta-BHC, oxychlordane, heptachlor epoxide, toxaphene, dicofol, dacthal, endosulfan I, endosulfan II, endosulfan sulfate, octachlorostyrene, Kepone (with additional 12mls 1% methanol in hexane).

C. Silica Gel:

1. SG Fraction I (100 ml petroleum ether)
   n-dodecane, n-tridecane, n-tetradecane, ocylcyclohexane, n-pentadecane, nonycyclohexane, n-hexadecane, n-heptadecane, pristane, n-octadecane, phytane, n-nonadecane, n-eicosane.
2. SG Fraction II (100 ml 40% methylene chloride in petroleum ether followed by 50 ml methylene chloride)
   napthalene, fluorene, phenanthrene, anthracene, fluoranthrene, pyrene, 1,2-benzanthracene, chrysene, benzo [b] fluoranthrene, benzo [k] fluoranthrene, benzo [e] pyrene, benzo [a] pyrene, 1,2:5,6-dibenzanthracene, benzo

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[g,h,i] perylene.

D. Silicic Acid:

1. <u>SA Fraction I</u> (20 ml petroleum ether)

   HCB, mirex

2. <u>SA Fraction II</u> (100ml petroleum ether)

   PCB's, p,p'-DDE (splits with SA III)

3. <u>SA Fraction III</u> (20 ml mixed solvent: 1% acetonitrile, 80% methylene chloride, 19% hexane)

   alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, oxychlordane, heptachlor epoxide, gamma-chlordane, trans-chlordane, toxaphene, o,p'-DDE, alpha-chlordane, p,p'-DDE (splits with SAII), o,p'-DDT, cis-nonachlor, o,p'-DDT, p,p'-DDD, p,p'-DDT, dicofol.

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APPENDIX C

Analytical Methods for Trace Elements.

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% MOISTURE

For animal tissue and sediments of sufficient size, moisture was determined by placing a weighed aliquot of the sample in a Fisher Isotemp oven and drying at 103-105°C. The dried sample was then weighed and the data entered into a computer program to generate the % moisture and final report.

Plants, and samples too small for oven dried moisture determination had the % moisture calculated from the moisture lost during the freeze-drying in the Labcono Freeze-Dryer 8. The data was entered into a computer program to generate a % moisture and final report.

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TOTAL VOLATILE SOLIDS (TVS)

Aliquots of oven-dried samples were weighed into previously fired crucibles. The crucibles with samples were then placed in an oven and fired at 550°C for a minimum of 4 hours. The crucibles were allowed to partially cool and then were placed in a desicator until they cooled to room temperature and were weighed.

The oven-dried weights and the weights of the samples after firing were entered into the computer and TVS was calculated. The formula used to calculate TVS follows.

$$\frac{\text{Oven-dry Sample Weight - Fired Sample Weight}}{\text{Oven-dry Sample Weight}} = \text{TVS}$$

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HOMOGENIZATION

Large tissue samples, such as whole fish, were first run through a meat grinder one or more times depending on the size of the sample. An aliquot of the ground sample was weighed and frozen. For smaller tissue samples and plant samples the entire sample was weighed and then frozen. For sediments, the sample was mixed and an aliquot weighed and frozen. The frozen samples were placed in a Labcono Freeze Dryer 8 until the moisture had been removed. The dry samples were then weighed and further homogenized using a blender, or Spex Industries, Inc. Model 8000 mixer/mill with tungsten-carbide vial and balls.

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NITRIC - PERCHOLORIC DIGESTION - (ICP)

Approximately 0.5 g. of sample was weighed into a freshly cleaned 100 ml. quartz Kjeldahl flask. (Sediment samples and samples containing a high percent of silica were digested in 100 ml. teflon beakers.) For water samples, 50 ml. of sample were measured into a teflon beaker. Slowly 15 ml. of concentrated sub-boiled HNO_3 and 2.5 ml. of concentrated sub-boiled $HClO_4$ were added. Foaming may occur with some samples. If the foaming started to become excessive, the container was cooled in a beaker of cold water. After the initial reaction had subsided, the sample was placed on low heat until the evolution of dark red fumes had ceased. Gradually, the heat was increased until the HNO_3 began refluxing, samples were allowed to reflux overnight. (This decreased the chance for charring during the reaction with $HClO_4$.) After the refluxing, the heat was gradually increased until the HNO_3 had been driven off, and the reaction with $HClO_4$ had occured. When dense white fumes from the $HClO_4$ were evident, the samples were removed from the heat and allowed to cool. Two ml. of concentrated sub-boiled HCl were added. The flasks were replaced on the heat and warmed until the containers were hot to the touch or started to boil. They were removed from the heat, and 5-10 ml. of deionized water were added. Samples were allowed to cool. They were then diluted using deionized water in a 50 ml. volumetric flask and transferred to clean, labeled, 2 oz. polyethylene bottles.

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NITRIC - PERCHOLORIC DIGESTION - (SELENIUM)

Approximately 0.5 g. of sample was weighed into a freshly cleaned 100 ml. quartz Kjeldahl flask. (Sediment samples and samples containing a high percent of silica were digested in 100 ml. teflon breakers.) For water samples, 50 ml. of sample were measured into a teflon beaker. Slowly 15 ml. of concentrated sub-boiled HNO_3 and 2.5 ml. of concentrated sub-boiled $HClO_4$ were added. Foaming may occur with some samples. If the foaming started to become excessive, the container was cooled in a beaker of cold water. After the initial reaction had subsided, the sample was placed on low heat until the evolution of dark red fumes had ceased. Gradually, the heat was increased until the HNO_3 began refluxing, samples were allowed to reflux overnight. (This decreased the chance for charring during the reaction with $HClO_4$.) After the refluxing, the heat was gradually increased until the HNO_3 had been driven off, and the reaction with $HClO_4$ had occured. When dense white fumes from the $HClO_4$ were evident, the samples were removed from the heat and allowed to cool. Two ml. of concentrated sub-boiled HCl were added. The flasks were replaced on the heat and warmed until the containers were hot to the touch or started to boil. They were removed from the heat, and 5-10 ml. of deionized water were added. Samples were allowed to cool. They were then diluted using deionized water in a 50 ml. volumetric flask and transferred to clean, labeled, 2 oz. polyethylene bottles.

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NITRIC - PERCHOLORIC DIGESTION - (ARSENIC)

Approximately 0.5 g. of sample was weighed into a freshly cleaned 100 ml. Kjeldahl flask. (Sediment samples and samples containing a high percent of silica were digested in 100 ml. teflon beakers.) For water samples, 50 ml. of sample were measured into a teflon beaker. Slowly 15 ml. of concentrated sub-boiled HNO_3 and 2.5 ml. of concentrated sub-boiled $HClO_4$ were added. Foaming may occur with some samples. If the foaming started to become excessive, the container was cooled in a beaker of cold water. After the initial reaction had subsided, the sample was placed on low heat until the evolution of dark red fumes had ceased. Gradually, the heat was increased until the HNO_3 had been driven off, and the reaction with $HClO_4$ had occured. After this reaction, the samples were heated approximately 5 minutes, after dense white fumes from the $HClO_4$ were evident. The samples were removed from the heat and allowed to cool. Samples were diluted using deionized water in 50 ml. volumetric flasks and transferred to clean, labeled, 2 oz. polyethylene bottles.

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NITRIC REFLUX DIGESTION FOR MERCURY

Approximately 0.5 g. of sample was weighed into a freshly cleaned 50 ml. round bottom flask with 24/40 ground glass neck. For waters, 10 ml. of sample were measured into the flask. Five ml. of concentrated sub-boiled HNO_3 were added and the flask was placed under a 12 inch water-cooled condenser with water running through the condenser. The heat was turned up to allow the HNO_3 to reflux no more than 1/3 the height of the columns. Samples were allowed to reflux for two hours. Then the heat was turned off and the samples allowed to cool. The condensers were rinsed with 1% v/v HCl and the flasks removed. The samples were diluted with 1% v/v HCl in a 50 ml. volumetric flask and then transferred to clean, labeled, 2 oz. flint glass bottles.

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INDUCTIVELY COUPLED PLASMA (ICP)

The instrument used for ICP analysis was a Jarrell-Ash Model 1100 Mark III with 40 analytical channels, controlled by a Digital Equipment Company (DEC) 11/23+ computer with two RL02 disk drives, DEC VT100 terminal, and DEC LA120 decwriter III. The instrument was standardized with a series of seven standards containing 36 elements. After the standardization, the detection limit was determined by taking ten integrations of the zero standard; three times the standard deviation of the mean was used as the detection limit. Instrumental quality control samples were then analyzed to check the ICP operation. If the values were acceptable, the samples were then analyzed. Standards were run every 10-15 samples to check for drift. If the drift was more than 5%, the instrument was restandardized. After the analyses were completed, the data were transferred to the Perkin-Elmer LIMS 2000 computer for calculation. The final detection limit for each element was further increased by 4% of the magnitude of the spectral interferences from the other elements. The data were checked before calculation to correct for possible errors in sample number, weight, volumes and dilution. The data were calculated using the ICP calculation program written by ETSRC computer staff, which corrected for blanks, standard drift, spectral interferences, sample weight, sample volume, and dilution. After the quality control was reviewed, a final report was generated using a Hewlett-Packard laser jet printer.

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ARSENIC AND SELENIUM BY HYDRIDE

The Varian VGA-76 hydride generation accessory was mounted on either a Perkin-Elmer Model 603 AA or Model 3030 (B) AA. Electrodeless Discharge lamps (EDL) were used. The instrument and EDL settings were taken from the instrument manuals. The burner mount for a Perkin-Elmer Model 10 Hydride generator was modified slightly to hold the Varian quartz cell. The cell was aligned in the light path of the burner chamber and a very lean flame was used for heating the cell. The two stock solutions were 50% v/v sub-boiled HCl and 0.6% $NaBH_4$ in 0.5% NaOH for Selenium and concentrated sub-boiled HCL and 1% $NaBH_4$ in 0.5% NaOH for Arsenic. Samples were diluted with 10% v/v sub-boiled HCl. Standards were prepared by dilution of Fisher 1000 ppm stock with 10% v/v sub-boiled HCl in the range of 0 to 20 PPB. The instrument was standardized to read directly in PPB using S1 = 5.00 and S2 = 20.00. After standardization, the standardization was checked by reading other standards such as 2.00, 10.00 and 15.00 PPB and an instrumental quality control sample with a known value. If the standards and quality control were acceptable, the detection limit was determined by reading the zero standard 10 times, and twice the standard deviation of the mean was used as the detection limit. Samples were analyzed by taking an integrated reading for 3 seconds after the plateau was reached for the sample. This occured approximately 45 seconds after the sample tube was placed in the sample. Standardization was checked every 8-15 samples and approximately 10% of the samples were checked by the method of additions to monitor matrix effects. Matrix effects were usually not significant with the VGA-76. The data was corrected for drift of the standard curve and entered into the AA calculation program. This program corrected for blank, dilution, sample weight, sample volume and recorded the data in the LIMS database for report generation.

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ARSENIC IN FISH AND MARINE SAMPLES BY HYDRIDE

The Perkin-Elmer MHS-1 hydride generation accessory was mounted on either a Perkin-Elmer Model 603 AA or Model 3030(B) AA. An Electrodeless Discharge Lamp (EDL) was used. The instrument and EDL settings were taken from the instrument manuals. The cell was aligned in the light path of the burner chamber and a very lean flame used for heating the cell. The standard curve was run and a quality control sample of known concentration was then run to check the standard curve. Blanks and samples are run by diluting an aliquot of the digested sample to 10 ml. with 4% v/v $HClO_4$. The amount of sample used varied with the Arsenic concentration. Samples were analyzed using the method of standard additions. The peaks, from the recorder tracing, were measured with a ruler and the slope and intercept calculated on a calculator. The data were entered into the AA calculation program. This program corrected for the blank, dilution factors, sample weight, sample volume and recorded the data in the LIMS database for report generation.

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MERCURY - COLD VAPOR ATOMIC ABSORPTION

Equipment used for Cold Vapor Atomic Absorption include: Perkin-Elmer Model 403 AA; Perkin-Elmer Model 056 recorder; Technicon Sampler I; Technicon Pump II; a glass cell with quartz windows and capillary tube for entry and exit of the mercury vapor; and a liquid-gas separator. The samples were placed in 4 ml. sample cups at least 3/4 full. The samples were mixed with hydroxylamine for preliminary reduction, then stannous chloride for reduction to the mercury vapor. The vapor was separated from the liquid and passed through the cell mounted in the light path of the burner compartment. The peaks were recorded and the peak heights measured. The standardization was done with at least 5 standards in the range of 0 to 10 ppb. The correlation coefficient was usually 0.9999 or better and must have been at least 0.999 to have been acceptable. A standard was run every 8-10 samples to check for drift in the standardization. This was usually less than 5%. Standards were preserved with 10% v/v HNO_3, 1% v/v HCl and 0.05% w/v $K_2Cr_2O_7$. The solution concentrations were calculated and the data entered into the AA calculation program which corrected for blank, dilution, sample weight, sample volume and entered the data into the LIMS system for report generation.

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Appendix D. Trace element concentrations in sediment ($\mu g/g$ dry weight).

Sample Number	% Moisture	% TVS[1]	Ag	Al	As	B	Ba	Be
PB1-SED-M1	39.9	3.2	<2	15200	4.8	21	38.6	0.2
PB2-SED-M1	32.9	5.1	<2	17500	4.1	24	46.2	0.3
PB3-SED-M1	32.8	3.7	<2	14800	3.3	12	45.7	0.3
PB4-SED-M1	32.5	3.4	<2	16300	3.4	7	41.0	0.3
PB5-SED-M1	61.1	12.4	<2	25400	10.0	23	86.4	0.57
PB6-SED-M1	31.7	4.2	<2	18800	5.5	7	49.8	0.36
PB7-SED-M1	28.1	3.7	<2	17100	4.4	9	42.1	0.3
MP1-SED-M1	53.4	10.9	<2	19400	7.0	31	59.4	0.41
MP1-SED-M2	48.6	9.1	<2	21300	7.3	16	70.2	0.43
MP2-SED-M1	35.5	3.4	<2	14700	4.9	10	47.4	0.3
MP3-SED-M1	47.3	6.3	<2	16700	6.0	23	47.2	0.36
FB1-SED-M1	47.3	6.5	<2	20000	5.9	14	56.6	0.47
FB2-SED-M1	28.3	3.4	<2	13600	3.6	9	43.1	0.3
FB3-SED-M1	53.6	8.4	<2	21200	6.1	24	71.5	0.49
FB4-SED-M1	51.0	7.3	<2	18000	5.6	25	48.8	0.4
GI1-SED-M1	25.0	2.8	<3	41600	9.2	19	73.7	0.62
LF1-SED-M1	54.0	8.7	<2	24800	7.0	22	71.0	0.48
LF2-SED-M1	55.9	9.0	3	23200	10.5	15	102.5	0.3
JL1-SED-M1	57.1	10.9	4	16700	4.5	30	98.0	0.3
NN1-SED-M1	63.8	12.5	<2	28900	7.1	26	70.0	0.74
LI1-SED-M1	78.1	17.3	<3	29700	15.2	30	89.5	0.81
BI1-SED-M1	68.8	11.9	3	21200	18.4	32	79.0	0.38
IS1-SED-M1	33.6	3.8	<2	18900	4.2	9	48.1	0.2
SB1-SED-M1	29.5	2.0	<2	11100	3.1	6	26.5	<0.1
SB1-SED-M2	26.9	2.3	<2	15300	2.9	8	40.1	0.2
SB2-SED-M1	46.7	6.0	<2	17800	4.9	22	57.3	0.3
SB2-SED-M3	30.7	3.6	<2	13800	4.2	17	33.8	0.1
SB3-SED-M1	43.8	3.4	<2	15800	5.4	17	44.3	0.2
SB3-SED-M3	47.7	5.6	<2	15600	5.5	17	43.0	0.2
SB4-SED-M1	56.6	7.6	<2	17700	5.6	20	53.5	0.35
SB5-SED-M2	31.6	2.1	<2	8410	4.5	9	28.9	<0.1
SB5-SED-M3	44.4	5.3	<2	15600	4.8	16	51.8	0.3
SB6-SED-M1	36.7	7.2	<2	11100	5.0	15	39.8	0.2

[1] Total Volatile Solids

<00004047.tif>

Appendix D, continued. Trace element concentrations in sediment (μg/g dry weight).

Sample Number	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo
PB1-SED-M1	0.7	20	7.9	11750	0.040	4720	112	<2
PB2-SED-M1	<0.6	29	11.0	16400	0.030	7630	159	<2
PB3-SED-M1	<0.6	29	9.1	15000	0.030	7370	158	<2
PB4-SED-M1	<0.6	27	10.0	14500	0.030	6700	142	<2
PB5-SED-M1	<0.6	68	37.2	36700	0.053	14700	267	<4
PB6-SED-M1	<0.6	42	19.0	20700	0.040	8500	192	<3
PB7-SED-M1	<0.6	26	10.0	16400	0.040	7040	156	<2
MP1-SED-M1	<0.6	49	26.0	25650	0.073	10550	223	<3
MP1-SED-M2	<0.6	50	24.0	25900	0.065	10600	226	<3
MP2-SED-M1	<0.6	29	11.0	13700	0.030	7060	143	<2
MP3-SED-M1	0.8	30	15.0	17400	0.062	7440	153	<2
FB1-SED-M1	<0.6	39	18.0	23200	0.040	8990	178	<3
FB2-SED-M1	<0.6	26	11.0	14900	0.030	5910	148	<2
FB3-SED-M1	<0.6	49	22.0	27100	0.053	10500	213	<3
FB4-SED-M1	0.8	37	19.0	21400	0.050	8950	175	<3
GI1-SED-M1	<0.7	160	62.7	63800	0.020	15000	340	<6
LF1-SED-M1	<0.7	58	33.4	27500	0.068	11600	251	<3
LF2-SED-M1	1.0	50	31.3	70350	0.065	10750	265	<6
JL1-SED-M1	1.0	36	29.0	105000	0.050	8720	521	<9
NN1-SED-M1	1.0	54	41.8	39700	0.079	14300	281	<4
LI1-SED-M1	1.0	66	58.8	73100	0.070	16100	302	<6
BI1-SED-M1	0.9	53	37.3	82200	0.070	12800	407	<7
IS1-SED-M1	<0.6	29	13.0	16500	0.030	7320	159	<2
SB1-SED-M1	<0.6	19	7.9	12400	<0.02	6020	136	<2
SB1-SED-M2	<0.6	22	7.7	12700	0.020	6320	145	<2
SB2-SED-M1	<0.6	34	18.0	22100	0.050	9420	194	<3
SB2-SED-M3	<0.6	16	9.4	11400	0.030	5170	109	<2
SB3-SED-M1	0.8	25	12.0	14200	0.040	6590	131	<2
SB3-SED-M3	<0.6	30	15.0	17200	0.053	7970	155	<2
SB4-SED-M1	0.7	37	22.0	26100	0.071	10900	222	<3
SB5-SED-M2	<0.6	17	6.9	9390	0.040	5600	106	<2
SB5-SED-M3	0.8	32	14.0	17800	0.072	8930	171	<2
SB6-SED-M1	<0.6	32	10.0	16200	0.030	14100	179	<2

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Appendix D, continued. Trace element concentrations in sediment ($\mu g/g$ dry weight).

Sample Number	Ni	Pb	Se	Sr	Tl	V	Zn
PB1-SED-M1	15	<5	0.3	96.7	<5	24.0	25.0
PB2-SED-M1	23	6	0.3	91.0	<5	35.1	38.0
PB3-SED-M1	32	<4	<0.2	72.4	<5	36.4	31.0
PB4-SED-M1	24	<4	<0.2	81.9	<5	33.0	32.0
PB5-SED-M1	55	10	0.4	73.9	<6	69.8	81.7
PB6-SED-M1	34	6	<0.2	75.3	<5	50.0	47.0
PB7-SED-M1	26	<4	<0.2	93.4	<5	41.8	33.0
MP1-SED-M1	40	10	0.4	68.8	<5	50.7	63.2
MP1-SED-M2	37	6	0.4	70.6	<6	54.7	59.8
MP2-SED-M1	27	5	0.3	71.6	<5	30.0	28.0
MP3-SED-M1	23	8	0.5	74.4	<5	35.0	46.0
FB1-SED-M1	26	8	0.4	70.8	<5	45.2	50.4
FB2-SED-M1	19	8	0.2	54.9	<5	35.0	40.0
FB3-SED-M1	33	10	0.4	65.7	<5	51.2	65.4
FB4-SED-M1	26	7	0.5	73.4	<5	41.4	50.6
GI1-SED-M1	180	7	0.6	90.7	<6	70.8	80.0
LF1-SED-M1	53	17	0.5	80.0	<5	58.0	69.8
LF2-SED-M1	50	10	0.3	91.3	<5	66.8	84.4
JL1-SED-M1	33	<6	0.4	104.	<5	61.7	70.0
NN1-SED-M1	74	10	0.3	76.8	<6	69.1	164.0
LI1-SED-M1	57	9	0.55	111.	<5	85.9	283.0
BI1-SED-M1	44	8	0.5	99.7	<5	80.1	83.0
IS1-SED-M1	22	<5	0.2	96.1	<5	39.6	38.0
SB1-SED-M1	24	<4	<0.2	52.6	<4	27.0	28.0
SB1-SED-M2	25	<4	<0.2	85.9	<5	29.0	27.0
SB2-SED-M1	30	6	0.2	74.5	<5	40.1	50.0
SB2-SED-M3	16	<4	<0.2	76.1	<5	25.0	28.0
SB3-SED-M1	18	<4	0.2	84.3	<5	28.0	37.0
SB3-SED-M3	24	<4	<0.2	70.7	<5	33.0	44.4
SB4-SED-M1	31	6	0.3	63.4	<5	43.3	60.6
SB5-SED-M2	18	<4	<0.2	38.8	<4	17.0	25.0
SB5-SED-M3	29	6	<0.2	64.1	<5	34.0	47.0
SB6-SED-M1	66	<4	0.2	297.	<5	26.0	34.0

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Appendix E. Trace element concentrations in bivalves (μg/g dry weight).

Sample Number	% Moisture	Al	As	Be	Cd	Cr	Cu	Fe
Littleneck Clam								
PB1-LNC	81.9	8.6	21.	0.03	3.10	1.5	5.67	173
PB2-LNC	86.2	65.1	21.	<0.03	1.30	1.5	8.02	467
PB7-LNC	82.5	107	20.	0.03	3.10	4.3	7.11	409
MP2-LNC	82.5	25	15.	<0.03	1.70	0.78	7.01	267
MP3-LNC	85.4	91	16.	<0.03	0.89	1.1	6.61	379
FB4-LNC	81.5	139	18.	<0.03	2.10	1.7	8.37	614
Softshell Clam								
PB3-SSC	88.6	354	6.4	<0.03	0.78	2.2	11.8	643
MP1-SSC	91.8	205	4.9	<0.03	0.64	1.5	12.7	469
MP3-SSC	89.0	1310	10.	<0.03	0.63	4.6	16.4	2510
FB3-SSC	91.6	881	5.8	<0.03	0.85	2.2	10.4	1110
American Oyster								
IS1-OYS	88.3	98.2	6.5	<0.03	7.25	1.6	126.	660

Sample Number	Hg	Mn	Ni	Pb	Se	Tl	Zn
Littleneck Clam							
PB1-LNC	0.089	6.3	2.0	<0.5	2.9	<0.4	61.9
PB2-LNC	0.26	10.0	9.9	<0.5	4.8	<0.5	87.7
PB7-LNC	0.17	8.3	3.5	0.6	4.1	<0.4	64.4
MP2-LNC	0.15	7.3	3.0	<0.5	3.2	<0.5	63.5
MP3-LNC	0.16	6.5	6.4	<0.5	2.8	<0.5	80.9
FB4-LNC	0.18	4.9	3.5	0.6	3.8	<0.5	62.0
Softshell Clam							
PB3-SSC	0.24	9.4	3.1	0.8	2.5	<0.5	80.1
MP1-SSC	0.22	6.9	3.8	<0.5	1.9	<0.5	130
MP3-SSC	0.13	21.0	5.3	2.0	2.6	<0.5	295
FB3-SSC	0.11	13.9	3.6	0.7	2.3	<0.5	110
American Oyster							
IS1-OYS	0.33	34.2	<1.0	0.9	2.5	<0.5	2260.0

<000041050.tif>

Appendix F. Trace element concentrations in eelgrass ($\mu g/g$ dry weight).

Sample Number	% Moisture	Al	As	Be	Cd	Cr	Cu	Fe
PB1-EG	77.5	2650	1.6	0.05	3.6	5.7	5.35	2840
PB2-EG	85.1	4790	7.3	0.06	1.9	16.	7.2	7620
PB3-EG	80.9	6820	5.9	0.09	1.4	35.2	11.8	10300
PB4-EG	82.9	5250	2.7	0.08	2.2	15.	8.59	6360
MP3-EG	86.2	7320	3.4	0.12	2.0	17.	9.44	8420
PB7-EG	88.1	3890	7.8	0.05	1.1	14.	10.6	6960
FB2-EG	86.5	1905	2.0	0.04	2.2	5.5	5.05	2835
FB4-EG	87.9	3120	2.0	0.05	2.2	7.6	5.93	3920

Sample Number	Hg	Mn	Ni	Pb	Se	Tl	Zn
PB1-EG	0.009	303	6.2	0.9	0.3	<0.6	21.5
PB2-EG	0.010	216	9.1	1.0	0.2	<0.7	34.1
PB3-EG	0.019	324	21.0	2.0	<0.2	<0.8	34.8
PB4-EG	0.010	155	9.8	1.0	0.3	<0.7	28.4
MP3-EG	0.022	148	12.0	2.7	0.4	<0.8	29.9
PB7-EG	0.019	121	9.6	1.0	0.3	<0.6	33.4
FB2-EG	0.010	118	4.6	1.5	<0.2	<0.5	33.7
FB4-EG	0.019	164	5.7	1.0	0.3	<0.6	28.7

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Appendix G. Concentrations of PAHs in sediment and biota ($\mu g/g$ wet weight).

Sample Number	% Moisture	% TVS[^]	Naptha-lene	Fluo-rene	Phenan-threne	Anthra-cene
SEDIMENT						
PB1-SED-01	32.7	3.2	0.01	<0.01	<0.01	<0.01
PB2-SED-01	37.8	5.1	0.01	<0.01	<0.01	<0.01
PB3-SED-01	27.4	3.7	<0.01	<0.01	<0.01	<0.01
PB4-SED-01	27.8	3.4	0.01	<0.01	<0.01	<0.01
PB5-SED-01	56.9	12.4	0.02	<0.01	<0.01	<0.01
PB6-SED-01	29.4	4.2	<0.01	<0.01	<0.01	<0.01
PB7-SED-01	48.2	3.7	0.01	<0.01	<0.01	<0.01
MP1-SED-01	48.1	10.9	0.03	<0.01	0.02	<0.01
MP1-SED-02	42.2	9.1	0.01	<0.01	<0.01	<0.01
MP2-SED-01	26.8	3.4	0.01	<0.01	<0.01	<0.01
MP3-SED-01	42.0	6.3	0.01	<0.01	0.03	<0.01
FB1-SED-01	42.4	6.5	0.01	<0.01	<0.01	<0.01
FB2-SED-01	28.0	3.4	<0.01	<0.01	0.02	<0.01
FB3-SED-01	46.0	8.4	0.02	0.01	0.07	0.01
FB4-SED-01	45.6	7.3	0.01	<0.01	0.03	<0.01
GI1-SED-01	20.6	2.8	0.01	<0.01	0.01	<0.01
LF1-SED-01	51.8	8.7	<0.01	0.01	0.03	0.01
LF2-SED-01	51.0	9.0	0.01	0.03	0.03	0.01
JL1-SED-01	53.8	10.9	0.01	0.03	0.28	0.10
NN1-SED-01	57.8	12.5	0.01	<0.01	<0.01	<0.01
LI1-SED-01	78.0	17.3	<0.01	<0.01	<0.01	<0.01
BI1-SED-01	64.4	11.9	<0.01	<0.01	<0.01	<0.01
IS1-SED-01	28.6	3.8	0.01	<0.01	<0.01	<0.01
SB1-SED-01	21.4	2.0	0.01	<0.01	<0.01	<0.01
SB1-SED-02	20.8	2.3	<0.01	<0.01	<0.01	<0.01
SB2-SED-01	40.0	6.0	0.01	0.01	0.03	<0.01
SB2-SED-03	31.8	3.6	<0.01	<0.01	<0.01	<0.01
SB3-SED-01	34.2	3.4	<0.01	0.01	0.23	0.06
SB3-SED-03	40.6	5.6	0.01	<0.01	0.04	0.01
SB4-SED-01	51.2	7.6	0.03	0.07	0.30	0.05
SB5-SED-02	24.0	2.1	<0.01	<0.01	<0.01	<0.01
SB5-SED-03	24.0	5.3	0.01	0.01	0.04	0.01
SB6-SED-01	38.2	7.2	<0.01	<0.01	<0.01	<0.01
BIVALVES		% lipid				
PB1-LNC	83.3	1.15	0.01	<0.01	<0.01	<0.01
PB2-LNC	86.0	1.11	0.02	<0.01	<0.01	<0.01
PB3-SSC	90.0	1.10	0.01	<0.01	<0.01	<0.01
PB7-LNC	83.0	1.20	0.01	<0.01	<0.01	<0.01
MP1-SSC	92.0	1.25	<0.01	<0.01	<0.01	<0.01
MP2-LNC	82.8	1.11	0.01	<0.01	<0.01	<0.01
MP3-LNC	87.0	1.02	0.02	<0.01	0.02	<0.01
MP3-SSC	90.5	0.56	<0.01	<0.01	0.03	<0.01
FB3-SSC	92.0	0.80	0.02	<0.01	<0.01	<0.01
FB4-LNC	82.8	1.36	0.02	0.01	0.04	<0.01
IS1-OYS	85.0	2.08	0.03	0.02	0.01	<0.01
EELGRASS						
PB1-EG	84.0		<0.01	<0.01	0.06	<0.01
PB2-EG	82.0		<0.01	<0.01	0.06	<0.01
SB2-EG	76.0		<0.01	<0.01	0.11	<0.01
FB2-EG	84.5		<0.01	0.01	0.13	<0.01
FB4-EG	83.0		<0.01	0.01	0.13	<0.01

[^] Total Volatile Solids

<00004052.tif>

Appendix G, continued. Concentrations of PAHs in sediment and biota (μg/g wet weight).

Sample Number	Fluoran-threne	Py-rene	1,2-benzan-thracene	Chry-sene	Benzo(b)-fluoran-threne	Benzo(k)-fluoran-threne
SEDIMENT						
PB1-SED-01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
PB2-SED-01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
PB3-SED-01	0.01	0.01	<0.01	<0.01	<0.01	<0.01
PB4-SED-01	<0.01	0.01	<0.01	0.01	<0.01	<0.01
PB5-SED-01	0.01	0.02	<0.01	0.02	0.01	<0.01
PB6-SED-01	0.01	0.01	<0.01	<0.01	0.01	<0.01
PB7-SED-01	0.01	<0.01	<0.01	0.01	<0.01	<0.01
MP1-SED-01	<0.01	0.03	<0.01	0.02	0.01	<0.01
MP1-SED-02	0.01	0.02	<0.01	<0.01	0.01	<0.01
MP2-SED-01	0.01	<0.01	<0.01	<0.01	0.01	<0.01
MP3-SED-01	0.06	0.05	0.01	0.03	0.01	0.01
FB1-SED-01	0.02	0.02	<0.01	<0.01	0.01	<0.01
FB2-SED-01	0.05	0.04	0.01	0.01	0.01	<0.01
FB3-SED-01	0.26	0.22	0.05	0.05	0.06	0.02
FB4-SED-01	0.06	0.06	0.01	0.01	0.01	0.01
GI1-SED-01	0.01	0.01	<0.01	0.01	0.01	<0.01
LF1-SED-01	0.08	0.08	0.03	0.03	0.06	0.01
LF2-SED-01	0.05	0.06	0.09	0.03	0.02	<0.01
JL1-SED-01	3.6	2.1	0.90	1.1	0.18	0.43
NN1-SED-01	0.01	0.01	0.03	0.03	0.02	<0.01
LI1-SED-01	0.01	0.01	<0.01	0.02	0.01	<0.01
BI1-SED-01	<0.01	0.01	<0.01	<0.01	0.01	<0.01
IS1-SED-01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
SB1-SED-01	0.01	0.01	0.01	0.02	0.01	<0.01
SB1-SED-02	<0.01	0.01	<0.01	0.01	<0.01	<0.01
SB2-SED-01	0.04	0.08	0.02	0.05	0.02	0.01
SB2-SED-03	0.01	0.02	0.01	0.02	0.01	<0.01
SB3-SED-01	0.25	0.29	0.07	0.08	0.06	0.02
SB3-SED-03	0.06	0.06	0.01	0.02	0.01	0.01
SB4-SED-01	0.31	0.28	0.10	0.15	0.10	0.04
SB5-SED-02	0.02	0.02	0.03	0.06	0.06	<0.01
SB5-SED-03	0.07	0.11	0.07	0.11	0.04	0.01
SB6-SED-01	0.03	0.08	0.03	0.09	0.01	<0.01
BIVALVES						
PB1-LNC	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PB2-LNC	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PB3-SSC	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PB7-LNC	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
MP1-SSC	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MP2-LNC	0.01	<0.01	0.01	<0.01	<0.01	<0.01
MP3-LNC	0.04	0.03	<0.01	<0.01	<0.01	<0.01
MP3-SSC	0.02	0.01	<0.01	<0.01	<0.01	<0.01
FB3-SSC	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
FB4-LNC	0.03	0.02	<0.01	<0.01	<0.01	<0.01
IS1-OYS	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
EELGRASS						
PB1-EG	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PB2-EG	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SB2-EG	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
FB2-EG	0.02	<0.01	0.01	<0.01	<0.01	<0.01
FB4-EG	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

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Appendix G, continued. Concentrations of PAHs in sediment and biota (μg/g wet weight).

Sample Number	Benzo(e)-pyrene	Benzo(a)-pyrene	1,2,5,6-dibenzan-thracene	Benzo-(g,h,i)-perylene	Total
SEDIMENT					
PB1-SED-01	<0.01	<0.01	<0.01	<0.01	0.02
PB2-SED-01	<0.01	<0.01	<0.01	<0.01	0.02
PB3-SED-01	<0.01	<0.01	<0.01	<0.01	0.02
PB4-SED-01	0.03	<0.01	<0.01	<0.01	0.06
PB5-SED-01	<0.01	0.01	<0.01	<0.01	0.09
PB6-SED-01	0.01	<0.01	<0.01	<0.01	0.04
PB7-SED-01	0.01	<0.01	<0.01	<0.01	0.04
MP1-SED-01	0.01	0.01	0.01	0.01	0.14
MP1-SED-02	0.01	0.01	0.01	<0.01	0.08
MP2-SED-01	<0.01	<0.01	<0.01	<0.01	0.03
MP3-SED-01	0.02	0.02	<0.01	0.01	0.26
FB1-SED-01	0.01	0.01	<0.01	0.01	0.09
FB2-SED-01	<0.01	0.01	<0.01	0.01	0.16
FB3-SED-01	0.03	0.03	0.01	0.01	0.85
FB4-SED-01	0.01	0.01	0.01	0.02	0.25
GI1-SED-01	0.02	0.01	<0.01	0.01	0.10
LF1-SED-01	0.06	0.05	0.01	0.05	0.51
LF2-SED-01	0.02	0.02	0.03	0.02	0.42
JL1-SED-01	1.2	0.83	0.05	0.57	11.38
NN1-SED-01	0.03	<0.01	<0.01	<0.01	0.14
LI1-SED-01	<0.01	<0.01	<0.01	<0.01	0.05
BI1-SED-01	<0.01	0.01	0.02	0.03	0.08
IS1-SED-01	<0.01	<0.01	<0.01	<0.01	0.02
SB1-SED-01	0.02	0.01	0.03	0.01	0.14
SB1-SED-02	<0.01	<0.01	<0.01	0.01	0.03
SB2-SED-01	0.09	0.03	0.02	0.09	0.50
SB2-SED-03	0.02	0.01	0.02	0.03	0.15
SB3-SED-01	0.05	0.08	0.02	0.06	1.28
SB3-SED-03	<0.01	0.01	0.01	0.01	0.26
SB4-SED-01	0.12	0.10	0.03	0.09	1.77
SB5-SED-02	0.12	0.01	0.02	0.06	0.40
SB5-SED-03	0.25	0.11	0.13	0.32	1.29
SB6-SED-01	0.12	0.03	0.02	0.05	0.46
BIVALVES					
PB1-LNC	<0.01	<0.01	<0.01	<0.01	0.02
PB2-LNC	<0.01	<0.01	<0.01	<0.01	0.02
PB3-SSC	<0.01	<0.01	<0.01	<0.01	0.01
PB7-LNC	<0.01	<0.01	<0.01	<0.01	0.02
MP1-SSC	<0.01	<0.01	<0.01	<0.01	0.00
MP2-LNC	<0.01	<0.01	<0.01	<0.01	0.05
MP3-LNC	<0.01	<0.01	<0.01	<0.01	0.12
MP3-SSC	<0.01	<0.01	<0.01	<0.01	0.03
FB3-SSC	<0.01	<0.01	<0.01	<0.01	0.04
FB4-LNC	<0.01	<0.01	<0.01	<0.01	0.12
IS1-OYS	<0.01	<0.01	<0.01	<0.01	0.06
EELGRASS					
PB1-EG	<0.01	<0.01	<0.01	<0.01	0.06
PB2-EG	<0.01	<0.01	<0.01	<0.01	0.06
SB2-EG	<0.01	<0.01	<0.01	<0.01	0.11
FB2-EG	<0.01	<0.01	<0.01	<0.01	0.17
FB4-EG	<0.01	<0.01	<0.01	<0.01	0.14

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Appendix H. Concentrations of AHs in sediment and biota (μg/g wet weight).

Sample Number	% Moisture	% TVS[^]	N-dode-cane	N-tri-decane	N-tetra-decane	Octylcy-clohexane
SEDIMENT						
PB1-SED-01	32.7	3.2	<0.01	<0.01	<0.01	<0.01
PB2-SED-01	37.8	5.1	0.02	0.02	0.01	<0.01
PB3-SED-01	27.4	3.7	0.01	0.01	0.01	<0.01
PB4-SED-01	27.8	3.4	<0.01	<0.01	0.01	<0.01
PB5-SED-01	56.9	12.4	0.01	0.01	0.02	<0.01
PB6-SED-01	29.4	4.2	0.01	0.01	0.01	<0.01
PB7-SED-01	48.2	3.7	0.03	0.03	0.01	<0.01
MP1-SED-01	48.1	10.9	0.05	0.04	0.03	0.02
MP1-SED-02	42.2	9.1	0.02	0.01	0.01	<0.01
MP2-SED-01	26.8	3.4	<0.01	<0.01	<0.01	<0.01
MP3-SED-01	42.0	6.3	0.02	0.01	0.01	<0.01
FB1-SED-01	42.4	6.5	0.03	0.03	0.02	0.01
FB2-SED-01	28.0	3.4	0.02	0.01	<0.01	<0.01
FB3-SED-01	46.0	8.4	0.02	0.01	0.01	<0.01
FB4-SED-01	45.6	7.3	0.01	0.01	0.01	<0.01
GI1-SED-01	20.6	2.8	0.03	0.02	0.01	<0.01
LF1-SED-01	51.8	8.7	0.03	0.02	0.01	0.01
LF2-SED-01	51.0	9.0	0.02	0.02	0.01	<0.01
JL1-SED-01	53.8	10.9	0.01	<0.01	<0.01	<0.01
NN1-SED-01	57.8	12.5	0.01	<0.01	<0.01	<0.01
LI1-SED-01	78.0	17.3	<0.01	<0.01	<0.01	<0.01
BI1-SED-01	64.4	11.9	0.01	<0.01	<0.01	<0.01
IS1-SED-01	28.6	3.8	0.01	0.01	<0.01	<0.01
SB1-SED-01	21.4	2.0	0.01	0.01	<0.01	<0.01
SB1-SED-02	20.8	2.3	<0.01	<0.01	<0.01	<0.01
SB2-SED-01	40.0	6.0	0.04	0.03	0.01	0.01
SB2-SED-03	31.8	3.6	0.02	0.01	<0.01	<0.01
SB3-SED-01	34.2	3.4	0.01	0.01	<0.01	<0.01
SB3-SED-03	40.6	5.6	0.02	0.01	0.01	<0.01
SB4-SED-01	51.2	7.6	0.04	0.03	0.02	<0.01
SB5-SED-02	24.0	2.1	0.02	0.02	0.01	<0.01
SB5-SED-03	24.0	5.3	<0.01	<0.01	0.01	<0.01
SB6-SED-01	38.2	7.2	0.02	0.02	<0.01	<0.01
BIVALVES		% lipid				
PB1-LNC	83.3	1.15	<0.01	<0.01	<0.01	<0.01
PB2-LNC	86.0	1.11	0.02	0.03	0.01	<0.01
PB3-SSC	90.0	1.10	0.05	0.05	0.02	0.01
PB7-LNC	83.0	1.20	0.02	0.02	0.01	<0.01
MP1-SSC	92.0	1.25	0.01	0.01	0.01	<0.01
MP2-LNC	82.8	1.11	0.02	0.02	0.01	0.02
MP3-LNC	87.0	1.02	0.03	0.03	0.02	<0.01
MP3-SSC	90.5	0.56	0.03	0.03	0.02	<0.01
FB3-SSC	92.0	0.80	0.01	<0.01	0.01	<0.01
FB4-LNC	82.8	1.36	0.01	0.01	0.01	<0.01
IS1-OYS	85.5	2.01	0.04	0.03	0.02	0.01
EELGRASS						
PB1-EG	84.0		0.05	0.12	0.29	0.07
PB2-EG	82.0		0.08	0.13	0.30	0.09
SB2-EG	76.0		0.05	0.15	0.39	0.13
FB2-EG	85.5		0.05	0.20	0.50	0.16
FB4-EG	83.0		0.11	0.21	0.52	0.17

[^] Total Volatile Solids

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Appendix H, continued. Concentrations of AHs in sediment and biota (µg/g wet weight).

Sample Number	N-penta-decane	Nonylcy-clohexane	N-hexa-decane	N-hepta-decane	Pris-tane	N-octa-decane
SEDIMENT						
PB1-SED-01	0.01	<0.01	<0.01	0.10	<0.01	0.01
PB2-SED-01	0.03	<0.01	0.02	0.16	0.01	0.02
PB3-SED-01	0.02	<0.01	0.01	0.09	<0.01	0.01
PB4-SED-01	0.02	<0.01	0.01	0.04	0.06	0.01
PB5-SED-01	0.03	<0.01	0.03	21.0	<0.01	0.02
PB6-SED-01	0.01	<0.01	0.01	0.13	0.01	0.01
PB7-SED-01	0.02	<0.01	0.02	0.05	0.01	0.02
MP1-SED-01	0.04	0.01	0.04	0.14	0.04	0.05
MP1-SED-02	0.01	<0.01	0.02	0.07	0.02	0.01
MP2-SED-01	0.02	<0.01	0.01	0.07	0.04	0.02
MP3-SED-01	0.03	<0.01	0.02	0.08	0.03	0.02
FB1-SED-01	0.18	<0.01	0.06	1.7	<0.01	0.04
FB2-SED-01	<0.01	<0.01	<0.01	0.11	<0.01	0.01
FB3-SED-01	0.02	<0.01	0.02	0.41	0.03	0.02
FB4-SED-01	0.02	<0.01	0.01	0.10	0.02	0.02
GI1-SED-01	0.02	<0.01	0.03	0.03	0.03	0.04
LF1-SED-01	0.02	<0.01	0.02	0.12	0.02	0.02
LF2-SED-01	0.04	0.01	0.04	1.3	0.01	0.05
JL1-SED-01	<0.01	<0.01	0.01	0.05	0.02	0.02
NN1-SED-01	0.01	<0.01	0.01	0.05	0.01	0.02
LI1-SED-01	<0.01	<0.01	0.01	0.08	<0.01	0.01
BI1-SED-01	<0.01	<0.01	0.01	0.13	0.01	0.02
IS1-SED-01	<0.01	<0.01	<0.01	0.06	<0.01	0.02
SB1-SED-01	<0.01	<0.01	<0.01	0.01	<0.01	0.01
SB1-SED-02	<0.01	<0.01	<0.01	0.01	<0.01	0.01
SB2-SED-01	0.04	<0.01	0.03	0.09	0.04	0.03
SB2-SED-03	0.05	<0.01	0.02	0.09	0.02	0.02
SB3-SED-01	0.06	<0.01	0.01	0.12	0.02	0.02
SB3-SED-03	0.02	<0.01	0.01	0.06	0.03	0.01
SB4-SED-01	0.03	0.01	0.03	0.09	0.08	0.03
SB5-SED-02	0.01	<0.01	0.01	0.05	0.02	0.01
SB5-SED-03	0.02	<0.01	0.02	0.10	0.06	0.02
SB6-SED-01	0.02	<0.01	0.02	0.04	0.04	0.02
BIVALVES						
PB1-LNC	0.02	<0.01	0.03	0.05	0.02	0.03
PB2-LNC	0.02	<0.01	0.02	0.04	0.03	0.03
PB3-SSC	0.02	<0.01	0.03	0.07	0.02	0.03
PB7-LNC	0.04	<0.01	0.02	0.08	0.04	0.02
MP1-SSC	0.01	<0.01	0.02	0.04	0.02	0.02
MP2-LNC	0.04	0.01	0.04	0.05	0.05	0.03
MP3-LNC	0.03	<0.01	0.03	0.04	0.03	0.03
MP3-SSC	0.02	<0.01	0.02	0.08	0.02	0.03
FB3-SSC	0.01	<0.01	0.02	0.11	0.01	0.02
FB4-LNC	0.02	<0.01	0.02	0.08	0.02	0.02
IS1-OYS	0.06	<0.01	0.06	0.14	0.01	0.03
EELGRASS						
PB1-EG	13.5	0.21	3.2	14.0	0.97	1.2
PB2-EG	7.1	0.27	2.4	9.6	1.2	1.3
SB2-EG	6.3	0.39	1.8	6.9	1.9	1.6
FB2-EG	9.0	0.50	2.2	8.0	2.1	2.1
FB4-EG	13.0	0.51	2.3	8.2	2.0	2.1

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Appendix H, continued. Concentrations of AHs in sediment and biota (µg/g wet weight).

Sample Number	**Phy-tane**	**N-nona-decane**	**N-eico-sane**	**Total**
SEDIMENT				
PB1-SED-01	0.01	0.09	0.03	0.25
PB2-SED-01	0.05	0.05	0.01	0.40
PB3-SED-01	0.02	0.03	0.01	0.22
PB4-SED-01	<0.01	0.02	0.01	0.18
PB5-SED-01	0.09	0.07	0.03	21.31
PB6-SED-01	0.01	0.02	0.01	0.24
PB7-SED-01	0.01	0.02	0.01	0.23
MP1-SED-01	0.10	0.11	0.04	0.71
MP1-SED-02	0.04	0.03	0.02	0.26
MP2-SED-01	<0.01	0.05	0.01	0.22
MP3-SED-01	0.02	0.10	0.02	0.36
FB1-SED-01	0.13	0.04	0.02	2.26
FB2-SED-01	0.02	0.01	<0.01	0.18
FB3-SED-01	0.02	0.04	0.03	0.63
FB4-SED-01	0.01	0.06	0.02	0.29
GI1-SED-01	0.02	0.03	0.04	0.30
LF1-SED-01	0.08	0.04	0.02	0.41
LF2-SED-01	0.08	0.07	0.06	1.71
JL1-SED-01	0.03	0.05	0.04	0.23
NN1-SED-01	0.03	0.03	<0.01	0.17
LI1-SED-01	0.03	0.02	0.03	0.18
BI1-SED-01	0.02	0.02	0.02	0.24
IS1-SED-01	0.02	0.02	0.02	0.16
SB1-SED-01	<0.01	0.02	0.02	0.08
SB1-SED-02	<0.01	<0.01	<0.01	0.02
SB2-SED-01	0.01	0.05	0.03	0.41
SB2-SED-03	<0.01	0.07	0.02	0.32
SB3-SED-01	0.01	0.02	0.02	0.30
SB3-SED-03	0.01	0.04	0.02	0.24
SB4-SED-01	0.02	0.05	0.04	0.47
SB5-SED-02	<0.01	0.02	0.01	0.18
SB5-SED-03	0.01	0.05	0.03	0.32
SB6-SED-01	<0.01	0.03	0.02	0.23
BIVALVES				
PB1-LNC	<0.01	0.01	0.02	0.18
PB2-LNC	<0.01	0.01	0.01	0.22
PB3-SSC	0.01	0.01	0.02	0.34
PB7-LNC	0.01	0.02	0.01	0.29
MP1-SSC	0.01	0.01	0.01	0.17
MP2-LNC	0.01	0.01	0.02	0.33
MP3-LNC	0.02	0.01	0.01	0.28
MP3-SSC	0.02	0.01	0.01	0.29
FB3-SSC	<0.01	0.01	0.01	0.21
FB4-LNC	0.01	0.01	0.01	0.22
IS1-OYS	<0.01	0.01	0.01	0.42
EELGRASS				
PB1-EG	0.48	3.3	0.22	37.61
PB2-EG	0.59	3.2	0.24	26.50
SB2-EG	0.83	3.3	0.27	24.01
FB2-EG	1.1	4.3	0.32	30.53
FB4-EG	1.0	4.3	0.55	34.97